Bulletin OF THE INTERNATIONAL Oceanographic FOUNDATION

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THE MARINE LABORATORY, University of Miami, Coral Gables, Florida

THE SEAS CONTAIN *many strange creatures looking like nothing on earth and like nothing at sea with which we are familiar. The above photograph represents a creature which, though of considerable importance to mankind in many parts of the world, is not easily recognized except by scientists who are concerned with marine life.*

FOR THE STORY *behind this photograph see page 57.*

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FOUNDATION

Editorial Office: The Marine Laboratory, University of Miami, Coral Gables, Fla.

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HEAVY ACCUMULATIONS *of dead fish marking the edge of oily red water near Tampa Bay. Investigations of Red Tide have been aided by the cooperation of private individuals including boatmen, fishermen, etc.*

Science and the Public

By F. G. WALTON SMITH

FROM ITS EARLIEST DAYS, scientific research has been carried out in an atmosphere of varying degrees of mystery. A few centuries ago, the general illiteracy of the majority of people, and the practice of writing in Latin, did much to set the scientist apart as a kind of magician. Since the experimenters had no formal training of the kind we have today and some of them had not too clear an idea of the phenomena investigated, their own attitude did little to improve matters. The spread of education and enlightenment as well as the growth of scientific method and knowledge did much to dispel this aura of priestcraft and secrecy, but even today there is a certain gap between the scientist and the layman, not due to any deliberate lack of communication, but rather because of the ever growing complexity of the sciences and the ever increasing speci-

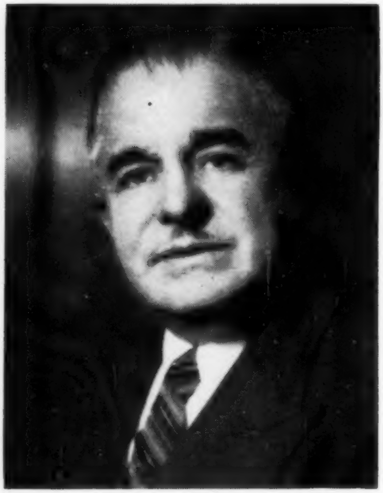
alization of the research worker. Moreover, although there is still a great deal of investigation accomplished by individual scientists, working alone, an increasing amount of research has come to involve teams of highly specialized men working with elaborate and expensive equipment.

The increasing use of elaborate equipment and facilities and of research by highly organized groups may increase the difficulty of direct communication between scientist and the public but, because of the considerable amount of private and public funds involved, it also increases the need for acquainting the public with the objectives and discoveries of science. It is also true that the results of scientific research are of little value to the world until they have been published and so made available to the scientific community at large. In general, their full value cannot be realized until the results have not only been known in scientific language to scientists but also, at least as far as their more important implications are concerned, made known to the general public in a language readily understood by all.

In the marine sciences there has perhaps been a much closer communion between science and the non-scientific world than in most fields of research. There is a close relationship of biological oceanography to the problems of the sea fisheries. There is also a need to recruit oceanographic scientists who are fairly well steeped

MRS. EUGENIE MARRON *and boat captain Howard Thuet read the surface thermometer during an expedition to the west coast of South America. Mrs. Marron took an active part in the scientific work of this expedition, financed by her husband, Mr. Lou Marron.*

in the ways of the sea. These, together with the attractions of saltwater angling, the collection of shore specimens and shells, have brought fishermen, yachtsmen, anglers and even the casual shore collector into closer contact with the scientist than would otherwise have been the case.



MR. LOU MARRON, *sponsor of the Pacific Billfish Expedition in* 1954, *also took an active part in the seagoing investigations.*

Research in marine biology especially has, as in other sciences, become more technical as it has advanced. The collecting and naming of sea creatures and fishes is not the major endeavor it was at the turn of the century but, with some exceptions, a tool which is subsidiary to more complex problems. Qualitative generalizations are giving way to more exact mathematical approaches and the complexities of electronics complicate the improved instruments which are being developed. Nevertheless it is the belief of The International Oceanographic Foundation that the bond between marine scientists and those who love the sea can be maintained and further encouraged. Even the most technical scientific endeavor may, in its essentials, be translated and made available in a clearly understood language to the yachtsman, angler or fisherman who wants to know more about the sea and such diverse problems as ocean currents, fish migrations and the slow, vast events which have made the history of the seafloor.

The interest is easy to see. How else would such noted gamefishermen as Charles F. Johnson, Wendell Anderson, the Lou Marrons, the John A. Mannings and others have switched from angling to the study of fishes? Or why else should a man past middle age and retired go back to

MR. JOHN MANNING, *well-known big game fisherman, has diverted his interest from angling to the scientific study of the tunas and billfishes.*

TWO BIG GAME ANGLERS *who are taking a serious interest in the study of big game fish, Mr. George Collier and Mr. Charles F. Johnson, President of the International Oceanographic Foundation. Between them is a bluefin tuna, one of the fishes which is being investigated under Mr. Johnson's sponsorship. Mr. Collier is responsible for new laboratory buildings devoted to fishery research.*

school for training in ichthyology? Many other anglers and fishermen too have cooperated in tagging and releasing fish as well as collecting them for study.

Large Scale Cooperation

Other examples of the cooperation of nonscientists come easily to mind. The Red Tide off the West Coast of Florida, in which fish died by the thousands due to the heavy plankton growth, is to a great extent influenced by the fluctuating currents which flow in these shallow waters. Simultaneous measurements over a wide area were needed in order to obtain a picture of the water circulation before the pattern could be changed. Dozens of cruisers and launches, manned by members of power squadrons and yacht clubs, joined the University of Miami in releasing colored waterproofed and numbered cards at predetermined points and in collecting them after a suitable lapse of time. Only in this way was it possible to measure the simultaneous movement of thousands of floating cards.

It is hoped that this type of collaboration will grow. In order to foster such understanding and cooperation, the work of marine scientists throughout of the world will be as clearly described and as well illustrated as possible as the Bulletin progresses. It is also hoped that those who go down to sea will find out for themselves what goes on in the marine laboratories of their part of the world. In the past, valuable observations have been made from commercial and pleasure craft on long cruises, in cooperation with research institutions. Even though the problems are more complex and technical today, the help of the intelligent and seriously interested seagoing layman will continue to be a valuable asset to the marine sciences.

Hybrid Sea

By SVEN G. SEGERSTRÅLE
University Museum of Zoology, Helsingfors, Finland

THE IDEA OF A WIDE SEA in which the bottom dredge or plankton net bring back to the surface a catch of not only saltwater but also freshwater creatures would seem to the marine biologist, at first sight, paradoxical. Normally he would expect freshwater life to be found only in lakes and rivers or, at best, in the estuaries through which the rivers empty into the sea. If, in addition to this, he were told that the shores of this wide sea showed no tidal rhythm and that the water's edge remained practically at the same level for weeks at a time, moving only in response to strong winds, he would be inclined to deny its existence.

But a little reflection would remind him that such an area exists—it is the Baltic Sea—the most extensive brackish water area of the world. It penetrates deep into the northern part of the European continent, separated from the Atlantic Ocean and the Arctic Sea by the Scandinavian Penin-

A SAMPLE *of the fish to be seen in Helsinki fish market. They include saltwater fishes such as herring, the cod (top left) and the turbot, the dark flatfish. Freshwater fishes include the whitefish, pike, ide and perchpike in the top row. Below are bream and perch.*

sula. To the biological oceanographer it has a special interest among all the brackish waters of the world, and this not only because of its size.

The Baltic is a kind of northern counterpart of the Mediterranean. Both of these seas are almost entirely enclosed by land and communicate with the Atlantic only by means of narrow outlets at the western end. However, in many other respects, the Baltic is just the opposite of the Mediterranean. Whereas the Mediterranean lies in a deep basin whose bottom is mainly over 12,000 feet below the surface, the Baltic is a shallow sea, for the most part less than 600 feet in depth. The temperature of the Mediterranean changes very little and it is fairly high, whereas the Baltic, which extends northward almost to the Arctic Circle, has very strong seasonal changes, relatively warm in the summer and covered with ice in the winter in its inner part. But the greatest difference is the saltness. Although fresh water enters the Mediterranean from rivers and by rainfall, the loss of moisture by evaporation is also great and this not only balances the freshening influences but actually makes the water saltier than the Atlantic. In the Baltic the evaporation is less and, in combination with the great volume of water delivered to it by hundreds of rivers, this causes the water to be greatly diluted. Most of the Sea has a saltness of less than 8 parts per thousand, to use the oceanographer's unit, compared with 35 parts per thousand for average Atlantic Ocean water. At the ends of the Gulf of Finland and the Gulf of Bothnia the water is almost fresh.

Compared with the rapid changes of saltness in estuaries, the Baltic changes its brackish condition so little that it provides a gigantic experimental aquarium, as it were, for studying the biological effects of salinity, which is one of the most important things controlling the distribution of marine

animals. If we go back in time, this impression of an experimental laboratory is strengthened, because during the glacial history of the sea, there were both freshwater and saltwater periods, experiments by nature on a grand scale.

Sea of Contrasts

The Baltic offers even more interesting points of study to the marine biologist, because of many contrasting conditions. Because of its elongation from North to South, there is a wide temperature range from one end to the other. There is also a wide difference in coastal conditions, from the open shores of the south to the labyrinth of archipelagoes of Finland and Sweden, a maze of islands more extensive than anywhere else in the world. Moreover, a series of depressions in the bottom serve to bring about well marked changes in such important conditions as bottom deposits, dissolved oxygen supply and the quantity of natural fertilizer in the water.

The kind of plant and animal life in the Baltic is of unusual interest. There is not only the peculiar mixture of sea, lake and genuine brackish water kinds of life, which is a normal characteristic of diluted marine areas, but also a special kind which is totally lacking on the shores of the oceans. These are the Arctic relicts, as the biologist calls them, brought south during the Glacial Age and left behind when the ice caps retreated. Some of these forgotten animals make up an important part of the Baltic sealife, especially in the inner part of the Sea, where the low winter temperatures make them feel as much at home as in Arctic waters. The fact is that the glacial relicts found in marine waters are almost entirely confined to the Baltic. This is caused not only by its low temperature, but also by the shape of its basin. The narrow connections with the Atlantic are in the south and the comparatively cold northern parts are cut off from the open ocean. Thus,

BALTIC FISHERMEN *do not realize how odd it seems to others that saltwater and freshwater fishes should be caught side by side. The fishing boats shown here bring both fresh and saltwater fishes from the Baltic Sea to the fish market. This market is in the inner harbor of Helsinki, which is the Finnish capital. To the right is the town hall.*

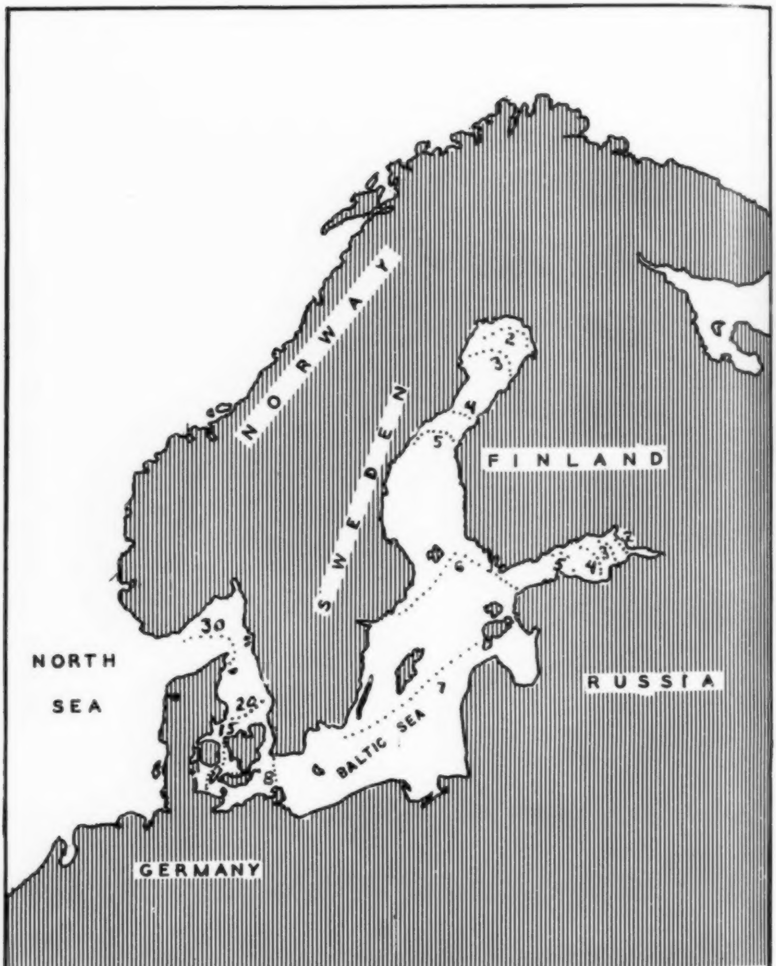
there is no way for Arctic relicts to travel and spread out of the Baltic. The well-known Swedish zoogeographer, Sven Ekman, has said it is difficult to conceive a better combination of conditions for developing a relict sea life than in the Baltic.

A Research Classic

Because of its peculiar interest to biologists in the neighboring countries, the Baltic has become one of the best known waters in the world. Together with the Dutch Zuider Zee, now transformed into the freshwater Ijsel Lake, the Baltic is the classical area of brackish water research. Those who have visited the Baltic will recognise the Sound or Öresund, the waters around Kiel in the south, and the maze of islands off the southwest of Finland, near the zoological station of Tvärminne as areas especially well studied. Due to the coordinating and encouraging influence of the International Council for the Exploration of the Sea, the biological work has been helped by studies of currents, temperatures, saltness and other physical measurements made over a period of more than half a century.

Finland stands apart from most other Baltic countries in some ways. Since the arctic coast of Petsamo was lost to Russia in the last war, Finnish biologists have had no access to an ocean of regular saltness and have been obliged to concentrate on the Baltic, with its comparatively poor range of life. But they are trying to turn this drawback into a virtue, by seizing the opportunity to study the special problems of a low salinity sea as it affects the life within it. Such problems include, for instance, the

AERIAL VIEW *of the waters of Tvärminne at the southwest coast of Finland. The only biological station in the world especially devoted to brackish water research is situated here. Although lake plants such as the common reed grow in the bays, there is also a dense growth of marine seaweeds along the rocky island shores. The open Baltic Sea is to the right.*



THE MAP SHOWS *the change from salt to fresh water at the entrance to the Baltic Sea. On the left, directly communicating with the North Sea, are the Skagerrak and Kattegat, separating Denmark from Norway and Sweden. Here the salinity drops from* 30 *to* 20 *parts per thousand. (Ocean salinity is about* 35.) *In the Baltic Sea itself the salinity drops from* 8 *parts per thousand in the South to* 2 *in the North.*

THE GLACIAL AGE *which has dominated the complicated history of the Baltic and which made it possible for Artic animals to enter this basin has also left its mark behind on every spot of the Baltic coast, in the form of ice-ground rocks, boulders and moraines. In this photograph are seen typical rocks and rock pools of the skerries near the Tvärminne Laboratory. Their great variation as to depth temperature, salinity and other factors makes them of unusual interest to the research biologist.*

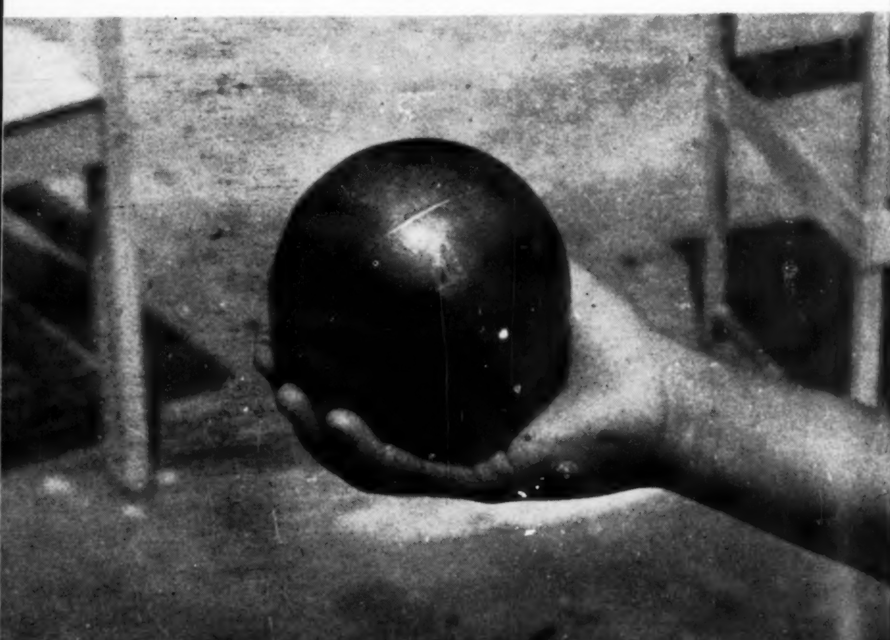
effect of lack of competition between different animals, caused by the absence of many of the species found in salt seas. This lack of competition influences the distribution of the sea life. Another important problem is the built-in chemical control of animals whereby they are able to balance water intake and output of the body. This is complicated by the presence or absence of salt in the water and explains why many freshwater fish will die in salt water and vice versa. Also of great interest is the question, how the Baltic received its three faunal elements, the lake, brackish water and seagoing kinds of animals. This problem is complicated on the one hand by the peculiar glacial and post-glacial history of the Baltic and on the other by the different origin of each kind. But, to the biologist and geologist, working together, this gives the Baltic a special fascination of its own.

What Is It?

IT IS COMMONPLACE to find objects washed ashore which have come from distant lands. For instance, coconuts or other tropical fruits, the seabean of the West Indies, known to Columbus before his discovery of the New World, and other exotic flotsam often are cast up on the shores of the Faroe Islands, between Scotland and Iceland. Whether or not this influenced the westward expeditions of the early Norsemen we do not know, but there is still a tinge of romance or, at the least, of curiosity to strange objects found on the beach.

In Florida and the West Indies, there is a similar trove of objects drifted from European waters, by the same clockwise circular system of Atlantic currents. The glass globes of fish nets and, in recent years, the metal floats and plastic floats are usually easy to identify, whether they came from England, Denmark or Portugal.

Colonel George Chadderton recently found on the beach of Man Island, near Harbour Island, in the Bahamas, a float that was not so easily distinguished. Made of a bronze or copper alloy it was about 5 inches in diameter and perfectly spherical. So far it could well have been a float but there was no lug, ring, or projection for attachment of any kind, and so far as we know, the first of its kind to be seen in these parts. Being perfectly smooth, and without means of roping into a net, it is probably not a fishing float. For the same reason it is unlikely to be a float valve from a storage cistern of a wrecked vessel. Possibly it is part of the actuating mechanism of a pressure activated mine. It would be interesting to find out just what was the origin of this strange object.



Waves

By HILARY B. MOORE
The Marine Laboratory, University of Miami

THE WAVE THAT KNOCKS a bather over, or carries a surf-rider in to shore, may have a surprisingly long personal history. During its life, which may be astonishingly long, it has, perhaps, travelled hundreds of miles; in fact, tidal waves may travel right across an ocean. Most ocean waves are created by the action of wind on water, and the swells which break on our shores may often be traced to an origin under far distant storms. They may even serve to warn us of the existence of such storms. Before the days of efficient hurricane warning services, the swell, which travelled faster than the storm, was often the first warning received. Looked at from the other point of view, a knowledge of the storms and the waves they are generating may be vital to the forecasting of conditions on far distant beaches, as we realized in planning the beach assaults in World War II.

It is interesting to trace, as an example, the life of one such storm wave. Suppose the wind were blowing for a whole day at a speed of 26 knots. If the storm was some 300 miles across, then the waves leaving the area would be fifteen feet high and 300 feet long. On a shore two thousand miles away these waves will appear several days later about 2½ feet high. So far they have been shrinking, but, as the water shallows, they build up again and are about five feet high when they break.

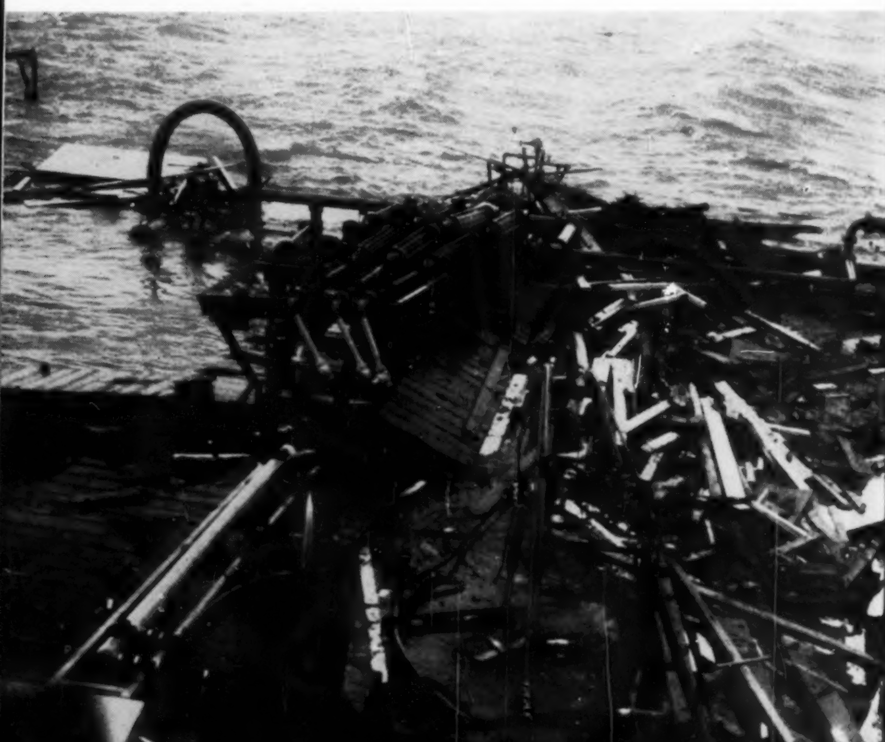
This was a small storm and the waves themselves not very large. There are stories of waves towering over the masts of big ships, though it is almost impossible to judge wave height at all accurately when tossing around under such conditions. Probably fifty feet high is about as large as a single wave ever grows, although

when two meet they may momentarily shoot up much higher.

Even a fifty foot wave is a dangerous monster to meet and can do devastating damage. Quite a small wave can knock one over and the forces a large one can produce are almost unbelievable. A pressure of nearly three tons per square foot was once measured in Scotland and there is a record of a twenty ton block of stone being lifted by waves onto a pier wall above high water mark. It is also on record that 135 pound stones have been thrown by waves to a height of a hundred feet and windows of a lighthouse, three hundred feet above sea level, have been broken by wave-tossed stones.

With such destructive forces, it is surprising that any life can survive on the shore. Many coasts, of course, are more or less protected and never suffer such extreme wave action. Even on the most exposed rocks, however, there is life, adapted to the fierce conditions, with thick shells, leathery tissues that bend under the shock, or other ways of survival. Down below low tide, too, the waves are smashing at the bottom, though less powerfully than between tide marks. Off wave-beaten Land's End, stones weighing up to a pound have been washed into lobster pots a hundred feet down. Wave movement drops off fast,

THE PHOTOGRAPH SHOWS *the corrosion test station operated by the International Nickel Company at Wrightsville Beach, North Carolina. (See article in Vol. 1, No. 2.) It was taken at the height of a hurricane and shows the damage done to the docks and testing installations by the wave action combined with high water level.*



though, with increasing depth and by the time the abyssal depths are reached there is nothing to stir their dust-fine sediments.

Ships and Stabilizers

Man has always had to fight the ocean waves, both on coasts and at sea. He has built harbors to protect his vessels from the waves and groins to save the beaches from erosion. He has built more seaworthy ships and vessels so big that only the heaviest storm waves can affect them. In recent years, there has been some success in providing vessels with stabilizers to reduce the roll and so save both damage to cargo and misery to passengers. Where stability is needed for scientific work some solution has been found in using submarines which can dive to a depth where the waves are at least much less serious. Man has dreamed, too, of not only circumventing the harm the waves can do, but also harnessing them to provide needed power. Here, as in so many other ways, the sea has enormous resources. How to tap these resources is one of the great problems that face the marine scientist. In many directions we are building up knowledge and trying out new theories, but it would be entering the realms of science fiction to guess how soon and how completely we will fulfill our aims.

Time and Tide

THE MEASUREMENT OF TIME by clock has been second nature to the human race for a considerable number of years. It is therefore somewhat of a shock to be reminded of the ancient use of other devices, such as the sundial. When we consider the great amount of calculation and elaborate machines used today for computing the precise timing of tides, it is even more of a shock when we hear of the reverse process, namely of tides being used to calculate time. Even more strange, this feat was carried out without any mathematical aid by village farmers and boatmen. Mr. John Lyman of the U.S. Navy Hydrographic Office draws our attention to the following footnote regarding the Faroe Islands in the Preliminary Report of the Scientific Exploration of the Deep Sea in H.M. Surveying vessel *Porcupine,* during the summer 1869. "It is worthy of mention that a discrepancy between the Ship's time and the Island time (as indicated by the Church clock) having led us to inquire into the mode in which the latter was regulated, we found that as there is not even a Sun-dial in the Islands, the time is kept by the turn of the tides, the periods of which are precisely known for each day of the lunation. As nearly all the intercourse between different villages and farmhouses is carried on by water, and as every Faroese is a boatman and fisherman as well as a farmer, it is not to be wondered at that he should be practically versed in the periodical changes of the currents by which his power of locomotion is so greatly influenced, and that these should take the place of the meridian passage of the sun (which he has no means of observing with precision) as his best time-regulators."

No Boundaries to Science

THERE ARE MANY PROBLEMS in marine science of a purely local nature, but even among these there are usually underlying principles of a broader, more universal kind which are true of the oceans as a whole. With the growth of oceanography, however, more and more effort is being given to problems which extend geographically far beyond the immediate neighborhood of any one laboratory. With this extension of the scientific frontier the importance of international cooperation becomes more and more obvious. Fortunately it is largely true that not only science but scientists know no frontiers in their pursuit of knowledge.

Marlins and Sailfish

The case is well illustrated by the recent return of Colonel John K. Howard, a member of The International Oceanographic Foundation Board of Trustees, from an extended expedition to Africa and Australia. During a period of over eight months he was collecting observations and measurements on the distribution of the marlins and sailfishes and sending frozen specimens back to Miami for further study. This study of large pelagic fishes, which themselves know no international boundaries, was only possible as a result of the generous and wholehearted cooperation of governments, fishery officials and commercial and sportsfishermen in the countries visited. His work took him along the West Coast of Africa from Dakar, Senegal, to the Volta River mouth, about 75 miles west of Accra, Gold Coast, in the Gulf of Guinea; the southeast coast of Africa from Natal to Bazarata Bay in Mozambique (Portuguese East Africa); the southern part of the coast of West Australia; and Spencer Gulf in South Australia. He also visited fisheries offices and marine research institutes in Egypt, Kenya Colony, Greece, Rome and England.

In passing, it is interesting to note that Colonel Howard, after spending a life time in the practice of law, had the fortitude to return to the classroom and earn a degree in biology, solely in order that he might turn his lifelong hobby of angling into the equally exciting study of ichthyology.

The International Year

As the practical attention of science has become more and more directed to natural phenomena which are worldwide in nature it has become more and more important to coordinate the scientific investigations of widely separated groups. For instance, in order to understand and forecast the distribution of cosmic rays or radio disturbances it is necessary that measurements should be made at the same moment and at as many stations as possible throughout the world. In another field, the need for this type of consideration and for simultaneous measurements has long been recognized and to a great extent served by weather stations. Without the synoptic observations of a network of such stations we should not have our weather maps and forecasts.

In order to help solve such problems of a worldwide nature a bold plan is being adopted by scientists of nations throughout the world under the title of the International Geophysical Year. Under this agreement, arrangements are being made for

COLONEL JOHN K. HOWARD (*right*) *pictured with a black marlin caught by him in New Zealand. Colonel Howard has recently carried on studies of the distribution of billfishes as far afield as Africa and Australia.*

specially synchronized measurements on weather, the earth's magnetism, the aurora, cosmic rays, activity of the sun, the movement of glacial ice and the problems of oceanography.

As part of this plan, oceanographers will also coordinate their work at sea and along the coasts during the year 1957-58, set aside for this concentrated effort. Wave recorders and tide gauges will be added to those already in existence, in order to add to the network of observations. Temperature measurements to a depth of about 600 feet will be taken at the selected stations. In addition to this, special attention will be paid to obtaining information which can be used for improving our knowledge of the oceanwide circulation of seawater.

The Sea Fisheries

The international cooperation of those concerned with the sea fisheries has long been recognized. Perhaps one of the most successful in promoting international research, and to a considerable extent, international agreement on control of fisheries, has been the Conseil International pour l'Exploration de la Mer, which joins together those countries which depend for their fisheries upon the North Sea and the neighboring fishing grounds.

Today the United Nations has inaugurated wide activities designed to improve and coordinate fishery investigation and administration throughout the world. The Food & Agricultural Organization and the Educational Scientific & Cultural Organization have been particularly active in developing and integrating fisheries and oceanographic work.

On a smaller scale, and with more circumscribed objectives, the Gulf and Caribbean Fisheries Institute will meet this year for the eighth consecutive year from October 31 to November 4, in Miami. This meeting is organized in such a way that the fishery scientists, those working in the fishing industry and conservation administrators join together in discussing the problems of fisheries as a whole, instead of each group meeting separately to discuss their own specialized interests. Thus, in 1953, the meeting was held jointly with the Fishing Boat Congress of the United Nations, in Miami, so that the problems of fishing boat financing and design could be discussed, as well as problems of marketing, fishery biology and even of electronic fish instruments. The basic idea is that it is of no use to find fish if there is no market for them and equally useless to develop more efficient fishing gear if the fish stocks in the ocean are already overfished.

In 1954 the meeting was held in Havana, with the assistance of the Banco de Fomento Agricola e Industrial de Cuba and was attended by experts from a number of countries in the Caribbean and elsewhere, as well as from many states of the U.S.A. The conferences are organized by a committee under the sponsorship of the Marine Laboratory of the University of Miami.

Mr. and Mrs. John Manning have recently returned from a six months stay in Chile, where they have been collecting specimens and data for the Marine Laboratory of the University of Miami and carrying out a survey of the distribution and migrations of the broadbill swordfish off the northern part of the coast of Chile. They were greatly aided in their work by the help and cooperation of government officials, the French Sardine Company of Chile and the Andes

Copper Mining Company.

Dr. F. G. Walton Smith, Executive Secretary of the Foundation, has recently returned from Venezuela where, as guest of the Asociacion Venezolana para el Avance de la Ciencia, he took part in a conference for the planning of a marine biological station. At the time of going to press he is in São Paulo, Brazil, as a guest of the United Nations Educational Scientific and Cultural Organization at a meeting of delegates of the Latin American countries for the purpose of developing and integrating marine research.

The Gamefish Research Committee

Although recently organized, the Gamefish Research Committee of The International Oceanographic Foundation is already functioning and has acquired members in many parts of the world. Headed by Mr. Charles F. Johnson, of Palm Beach, Florida, and Asheville, N.C., the committee's aim is to encourage gamefish research the world over.

To begin with, this action will take the form of reports by committee members of existing gamefish research and suggested research in those parts of the world with which each member is familiar. These reports will form part of a general study of the situation to be compiled by the committee.

In this way, each part of the world will be advised of the work of research now going on or contemplated. Further, the committee will be enabled to properly gauge the need for research in various seas, while marine scientists will benefit from the information contained in the reports. Thus, there will be an interchange of knowledge of gamefishes and information concerning them that will be made available in future issues of The International Oceanographic Foundation Bulletin.

At the present time, reports from many of the world's fishing areas are already beginning to come in from committee members. These, of interest to both scientists and sports fishermen, as well as commercial fisheries, will be prepared and published in future issues of the International Oceanographic Foundation Bulletin.

In addition to Charles F. Johnson as chairman, the Gamefish Research Committee includes Erl Roman, secretary; Dr. Roy B. Dean of Mexico City; Edward Gorham, Miami, Fla.; Col. R. Hone, Adelaide, Australia; John Manning of Beverly Hills, California; Count Warner Mörner of Stockholm, Sweden; J. Israel Pothier, Wedgeport, N. S.; Royden E. Terry of Walu Bay, Suva, Fiji Islands; and C. L. Waide of Lagos, Nigeria. Communications from those interested will be welcomed by the committee and should be addressed to the Chairman, Gamefish Research Committee, at the office of the Foundation.

Radioactivity in Ocean Science

By T. C. HELVEY
State University Teachers College, Oneonta, New York, and The Marine Laboratory, University of Miami.

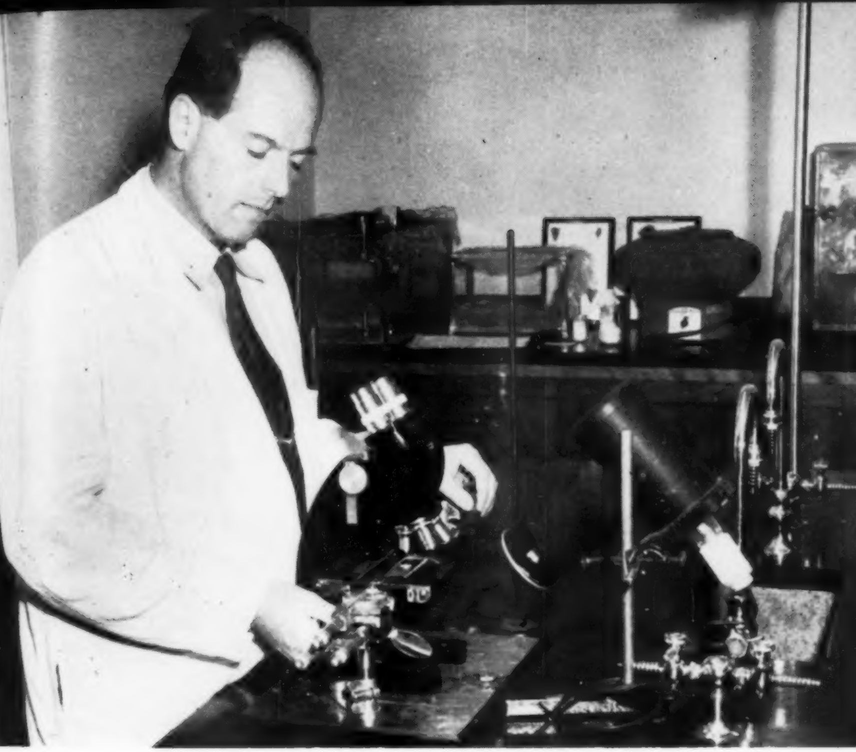
IF WE DISREGARD the tremendous possibilities of industrial atomic power plants, the greatest field for peacetime application of atomic energy is that of the radioactive isotopes.

How will this affect the ocean sciences? Let us first consider the nature of radioactive isotopes. They are chemical elements which have an unstable nucleus. They continually send out various types of radiations and in doing so they become broken down to physically and chemically different elements. These in turn break down until eventually a stable element is produced. The time it takes any radioactive isotope to be reduced to half of its present amount is called the half-life time. This time lapse varies enormously among the different isotopes and can be anywhere from a fraction of a second to millions of years.

The instruments used to measure the radiations which accompany the radioactive decay of the isotopes have such incredible sensitivity that the disintegration of a single atom may be detected. This sensitivity is of great importance for measuring small quantities of isotopes and it surpasses many thousand times the accuracy of any chemical or optical methods. Furthermore it is of great advantage that these easily detected radioactive isotopes are chemically the same as the corresponding more familiar stable elements.

These properties of the radioactive isotopes have brought about their present great popularity and usefulness in all kinds of scientific research. Already hundreds of results are reported which could not be achieved by any other means. It is only a few years since isotopes have been made available to everybody who has the necessary special training in handling radioactive materials, yet the possibilities for new applications seem to be endless. The technique of radioactive isotopes has been successfully

EQUIPMENT *to measure the pumping rate of the shipworm using a radioactive isotope.*



introduced in chemistry, physiology, medicine, ecology, metallurgy and many other sciences and technological fields. It was quite natural, therefore, that the sciences related to the ocean became interested in possible applications of this useful tool at an early date.

DR. T. CHARLES HELVEY *prepares the micro-manipulator designed by him to inject a radioactive isotope into the blood stream of a developing fish egg.*

Hazard?

Unfortunately there are certain problems in using radioactive isotopes which must be expertly recognized and coped with. One of the most important of these is the danger of harmful radiation effects upon the investigator and, in the case of field experiments, upon members of the public.

In the U.S.A. the Atomic Energy Commission, the authority in charge of safety and distribution of radioactive materials, has undertaken the necessary and satisfactory steps to safeguard health and property with a set of rules and regulations. If these rules are properly followed—and every specially trained scientist will precisely follow them for his own good—even large amounts of radioactive material, the so called "very hot stuff", can be safely handled and used. Because the public is far more familiar with the successful application of radioactive materials for warfare, laymen are liable to overemphasize the danger when used for research purposes. This sometimes turns out to be a handicap for harm-

less field experiments. But everybody can rest assured that there is no other field in research or technology where safety measures are better guarded than in applied nucleonics, as the science of isotopes is named.

What is used

For practical reasons the so called beta and gamma radiation emitting isotopes are mainly used. Among these, preference is given by many experiments to radio-phosphorus, radio-iodine and radio-carbon, but dozens more are listed as available in the catalog of the AEC. The phosphorus and iodine isotopes are energetic emitters, and so are easily detectable in smallest quantities. Also they have the great advantage of a very convenient half-life of a few days. This gives ample time for shipping the isotopes from Oak Ridge to the laboratory and to carry out the already lined up experiment, but on the other hand the radioactivity will diminish rapidly enough to render the samples and wastes soon completely harmless. Generally ten half-lives are considered as the limit during which special precautions are required in handling and keeping the isotopes. Radio-carbon has a half-life of many thousand years and emits a very weak radiation, but in spite of these shortcomings it is widely used and is indispensable in biochemical research.

The instruments for the detection and measurement of radiation must be carefully chosen for each experiment, because for instance radio-iodine emits mainly gamma rays but the well known Geiger counter is primarily sensitive to alpha and beta rays and will detect only about 3% of the gamma radiation. Therefore in such case, an instrument highly sensitive to gamma rays, the scintillation counter, must be used.

Neptune's special interest

It has been suggested in recent years that measurements of radioactive substances which were introduced naturally or artificially into the sea might help to solve oceanographic problems, which so far have resisted investigation. It is, however, unlikely that large current bodies of the ocean can be studied with this method. It seems much more practical to seek important information on the nature of horizontal and vertical mixing in the sea. The mixing of waters of different origin in the ocean is of vital importance to the distribution of fertilizer salts in the sea because this in turn controls the growth of life and eventually the condition of our commercial fisheries. The nature of vertical and horizontal mixing of waters is also of obvious importance in the consideration of waste disposal. How fast are industrial wastes mixed to a point where they are no longer harmful in bays and estuaries? How quickly can the intermingling of ocean water with that of a harbor carry away sewage pollution? By releasing small measured amounts of a radioactive substance at well chosen points, these questions may be answered. This is done by measuring the time taken for the radioactivity to be diluted to a certain level by the tidal mixing. In the same way important theoretical knowledge can be obtained about the general laws which govern the mixing of river and sea water anywhere. And one of the most important of the practical problems is the disposal of increasingly large amounts of radioactive wastes in such a way that they can be dispersed by natural water

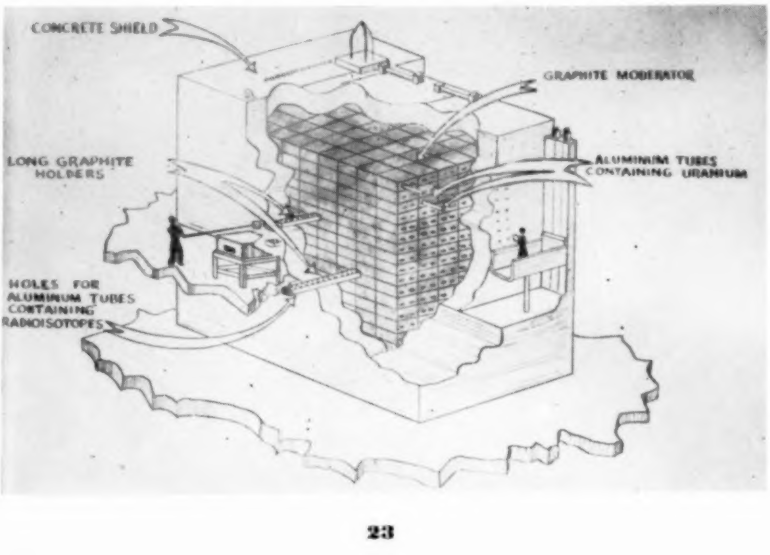
mixing processes without harm to life in the sea.

Another type of problem concerns the biological effects upon sealife of water from rivers and bays flowing into the ocean, bringing with them fertilizer material and dissolved chemicals and trace elements which may bring about increased or diminished growth of plankton. The "Red Tide", a growth of plankton poisonous to fish off the west coast of Florida, has been shown by scientists of the Marine Laboratory of the University of Miami and of the U.S. Fish & Wildlife Service to be dependent in some way upon the outflowing waters of the bays and rivers. Radioactive isotopes placed in the water could help to trace these movements.

The productivity or basic growth of life in the seas has an ever increasing economic importance for the food needs of the rapidly growing world population. Unfortunately too little is known of the factors which make for glut or scarcity in the sea. Experiments, which have already given some data on this subject, could be controlled and extended by means of radioactive isotopes. This is done by using radioactive carbon. Organisms are unable to distinguish between radioactive and stable carbon so that they will build up their bodies equally well from both. In this way the plankton becomes radioactively labelled and the manner of its increase may be observed more closely.

The migration, growth and mortality of fish and shrimp rank high on the list of urgent problems in all marine biological laboratories. Tagging these animals with metal or plastic tags is tedious and difficult and, in the case of young animals, an impossible undertaking. With radioactive tracers, animals of all sizes can be labelled and the detection of the tag-

DIAGRAM *of the arrangement of a nuclear reactor in which radioactive isotopes are being prepared.*



ged animals is easy and reliable by scanning over the catch with a Geiger tube. There is hope that even the study of vertical movement of microscopic sea creatures will be greatly aided by isotopes. Sometimes this can also be done indirectly. Radioactive isotopes are used to nourish microscopic sea plants; these are then eaten by minute crustaceans, such as tiny shrimps, etc., which in turn become slightly radioactive. Yet the very sensitive instruments will detect their presence in the water, as they migrate.

In the struggle with the pests of the sea, such as the shipworm and barnacles, science can get much help from the use of radioactive elements. One important problem is how to measure the leaching of antifouling paints, that is the dissolving of toxic copper from the protective paint surface and its effect upon the barnacles and sea grass which attach to ships' bottoms. We need to know this in order to make better paints so that, with cleaner hulls, yachts and merchant vessels may move faster with less loss of power.

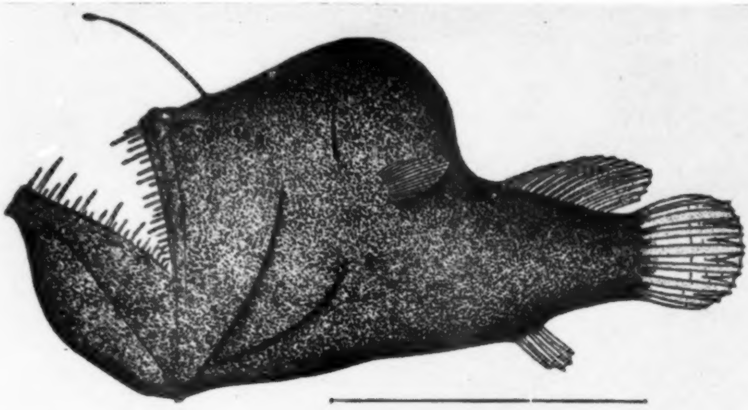
The application of isotopes in understanding the complex chemistry and physics of the body mechanism of marine animals and plants is so manifold that it is difficult to choose a representative example. There is, for instance, the precise measurement of the pumping rate of oysters. They would sense any dye or foreign material which scientists might use for this purpose, but they can be fooled by radioactive isotopes since radio active sodium, for instance, is chemically identical with the sodium in the sea water, and only a Geiger counter will detect its presence. Or there is the study of the fate of various food materials in marine animals. By incorporating a radioactive atom into some food its whereabouts can be detected by dissecting the animal after it has digested the material and by scanning the organs with a Geiger tube.

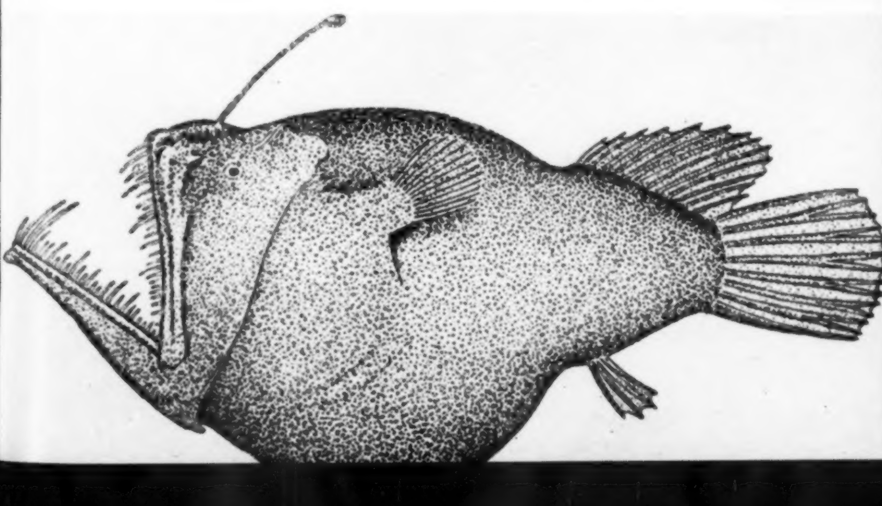
These are just a few of the many ways in which atomic energy byproducts may go to sea in the service of science. Perhaps they may help to give some idea of the immense versatility and usefulness of the radioactive isotopes as research tools in all fields of the ocean sciences.

Set a Fish to Catch a Fish

FISH FOR FOOD OR SPORT have been caught in many ways since the early days of mankind. The ancient Egyptians used two-pronged spears, the Greeks and Romans used tridents. Today, all over the world, young men equipped with masks and rubber powered guns engage in spearfishing for sport, not from boats, or the banks of a stream, but while swimming under water. The elaborate harpoon gun of the modern whaler is the up-to-date counterpart of the primitive spear used by our far ancestors when fishing for food. In the same

TWO DEEP SEA FISHES *which practice the art of angling. The rodlike projection from the front of the head is provided with a lure. The incurved teeth prevent escape of the prey.*





way the rod and reel of the present day angler, the nets, trawls, fishpots, traps, weirs, longlines and trolling gear of the modern commercial fisherman have an ancestry which goes back to early civilizations. They are the same in principle as they were thousands of years ago, though built of improved materials and in many ways of more efficient design.

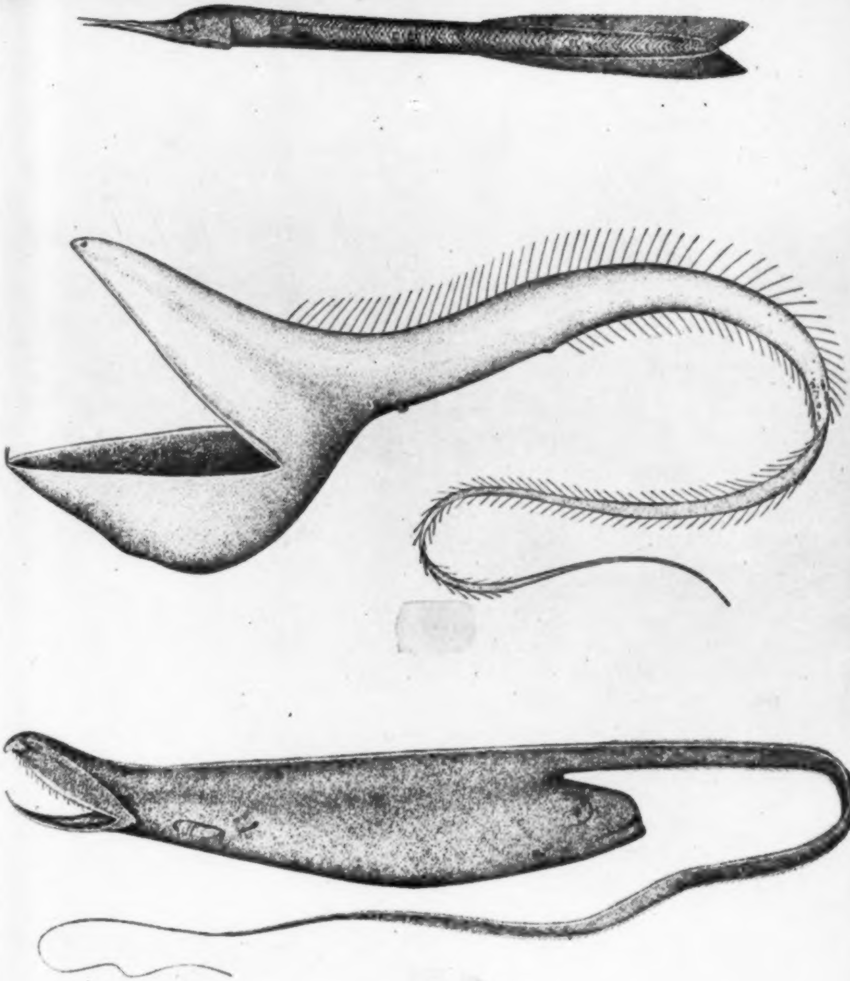
Long before mankind began to set his nets or to hurl his spears at fishes in the streams and shallow borders of the sea, there were other fishermen at work whose proficiency is still hard to beat. The seagulls, cormorants and pelicans continue to go about their business of catching fish. The sharks and fast swimming predatory fishes of the sea, the porpoises, the sea otters and seals account for a prodigious catch which in the aggregate is as much, if not more, than the catch of our fishing fleets. Some of these have even been harnessed by the fisherman to help him, much as the hunter uses a trained hawk to catch birds or a dog to retrieve game.

Angler fishes

The way of a hungry shark with a fish is obvious enough, but the ways of some other fishes which live on fish are odd indeed and are about as close to the way of the human angler as they could be. An entire family of fishes, in fact, is known as the angler fishes. Whereas the shark, the mackerels and most fishes in the sea rely upon superior speed to catch their prey, the angler fishes, known to science as the Pediculati, have adopted an ingenious device which is the nearest possible approach to using a fishing rod. In effect they lure the fishes on which they feed to within range of their landing net by means of an attractive bait which is carried by a fixed or jointed rod. The fishing rod in this case is really one of the foremost spines of the dorsal fin and the bait is a fleshy lump at the end of it.

The common angler fish, *Lophius piscatorius,* lives on the bottom partly concealed by mud or sand. In the best tradition of anglers it lies perfectly still, with its enormous mouth shut, while the wormlike end of its rod waves to and fro. Other fishes, through hunger or curiosity, approach the lure until they come within striking range. Then the great mouth opens with remarkable speed and engulfs the prey, which is prevented from escaping by the backwards directed teeth. Some of the deepsea anglers have a luminous lure at the end of the tip of the rod. In the total darkness of deep waters this is fatally attractive to the unfortunate victims. Because of the huge size of the angler's mouth the prey may be almost as large as the fisherman himself. Other deep sea fishes are able to dispense with the fishing rod but, instead, have luminous organs on the body which may play a part in attracting food. Some of these fishes are appropriately known as "Swallowers" and "Gulpers" and are able to swallow fishes many times their own size because of their ability to distend their mouths and throats.

Recently there has been much interest in the commercial possibilities of stunning fish or of directing them into nets by means of electric currents. The fishes themselves have long ago adopted this for their own use. The electric ray, on each side of its flat, rounded body, has an area in which numerous cells are modified to produce electricity. This is not really so amazing when we consider that electrical impulses are generated nor-



mally in small amounts by both nerve and muscle cells. In these particular fishes, however, the electrical impulses are considerable and the arrangement of cells, like those of a battery, builds up a total electric potential sufficient to stun or even kill smaller animals in the surrounding water. At the Bronx Zoo in New York the public has been accustomed to

TYPES OF FISHES, *especially adapted to angling in the dark waters of great depths. The huge mouth ensures that the rare victim will not be lost. In fact, as the lower picture shows, fishes of this kind are able to swallow foodfishes almost their own size, so that the image of the last meal shows through the distended stomach.*

the sight of another fish, the electric eel, in the act of lighting up a fluorescent lamp.

Trapped by eels

Altogether fishes have found some amazingly diverse ways of catching each other. The Greater Sand-eel, for instance, lies buried in the sand with its mouth open. A relative, the Lesser Sand-eel, when frightened, dives into what seems to be an opening in the sand and, as a result, the Greater Sand-eel is nearly always found to have one of the smaller fish in its stomach, arranged head down. Even this is overtopped in ingenuity by the archer fish, which is able to squirt a stream of water from its mouth, while at the surface, and shoot down the flies upon which it feeds.

If fishes have antedated man in the art of fishing, man has taken advantage of it in at least one case where he sets the fish to work for himself. The habit of the remora, or sucking fish, of attaching itself to other fishes or even to ships has been well known for a considerable time and, in fact, illustrations of this appear on Greek and Roman pottery. In 1494 Christopher Columbus witnessed the use of a captive sucker fish for capturing turtles. In parts of Australia, China and in Zanzibar and Mozambique the natives still hunt the sea turtle in this manner.

The remora has the first dorsal fin modified to form an oblong ridged plate above the head, which is the sucker. Its powers of adhesion are quite considerable. In the ordinary course of its life it attaches itself to sharks or other large fishes and enjoys a free ride until it comes across its food. When used for fishing the remora is tethered by a line around its tail, fastened to the native canoe. The native paddles towards the turtle until he can approach no closer without disturbing it. The remora during this time has remained attached to the underside of the canoe. It is now pulled off and thrown towards the turtle, to which it automatically swims and attaches itself. Once the remora is securely fixed to the turtle, the fisherman carefully plays his light line,

A REMORA *attached to a mako shark. These sucker fish have also been found on swordfish, manta rays, oceanic sunfish, whales and sea turtles.*

until the turtle is brought to boat. Since the turtle dives when alarmed and may either pull the remora off or break the line, the angler is obliged to use considerable skill in playing his catch.

The otter comes closer to the hunting dog when used in fishing. At one time it was used quite frequently for catching trout in European countries and is still used in the East. The otter is carefully trained and when not fishing is kept on a lead, like a dog. Usually he is employed to rout out fishes from among the rocks and, like a sheepdog, to herd them into a net. These creatures are fairly amenable to training and it is said that they develop a dog-like affection for the trainer.

Bird anglers

Probably the oddest kind of fishing is that in which the cormorant is used. Since this is one of the most voracious of fisheating birds it is well suited to the job. In China the fisherman works from a bamboo raft and uses cormorants which have been hatched from the egg by domestic hens. In this way the bird never knows a free existence. When old enough the bird is placed with adult trained birds, its wings clipped and a ring placed around the lower ends of the neck, below the gullet. The ring does not prevent feeding completely but will only allow small fishes to be swallowed completely. The birds fish from the owner's raft and when they catch a fish too large to swallow past the ring they return to the craft. They are undoubtedly influenced by the fact that a piece of fish is always given as a reward when the bird gives up its catch. This type of fishing has been carried out in Japan for over 1,000 years and for even longer in China.

Unfortunately for us, natural ways of angling such as these are designed to catch fish in comparatively small quantity. The angler might learn from the habits of the fishes themselves and improve his skill, but the commercial fisherman, who fishes far from shore and who needs fish by the ton to satisfy the huge demands of the human race, has a different problem. It is a problem that grows each day as 60,000 new mouths to feed are added by the growth of the human race. The solution will undoubedly be found and the world-wide catch improved at least partly by the efforts of marine scientists who are today bringing new electronic and acoustical devices into being, experimenting with electrified nets and learning more of the numerous factors which operate in the ocean to produce plenty or scarcity.

THE CORMORANT, *used for fishing in China. Around the neck is the ring which prevents the bird from swallowing its catch, and a leash for tethering it.*

Scripps in the Present Tense[1]

By THOMAS A. MANAR

Scripps Institution of Oceanography

EXCEPT FOR A SPRINKLE of islands, 5,000 miles of empty ocean lie between the Roaring Forties and the beaches of southern California. Waves born in the angry winter of the Southern Hemisphere cross this expanse in six to eight days. They travel with gradually diminishing force and gradually growing speed through the waters where winter is never known and into the Northern Hemisphere as it lies with its face to the sun. They arrive off southern California as low, regular swell. One strikes a ridge offshore, rises steeply, and bears landward on its flank a teetering surfrider. Others break just at the beach, rearing up head-high. There is a moment when the thin, transparent crest spills smoothly downward just before the whole mass crashes into a dazzle of blue-white surf.

We know that such waves arrive from the Southern Hemisphere because several years ago scientists from the University of California's Scripps Institution of Oceanography conducted research on such waves. By studying weather maps, they determined that waves of a specific direction, height, and period could only have originated in the Southern Hemisphere.

In its half-century of existence, the Scripps Institution has become a storehouse of information on the Pacific. The sheer size of this ocean is a little hard to realize. The 5,000 miles between the storm and the last expression of its energy is but one of the giant dimensions of the Pacific. It occupies almost half the surface of the globe. If all the continents were made into one, the resultant land mass would not entirely fill the Pacific Basin. The planet Mars, visible in some detail to our telescopes from 35 million miles away, is much smaller in area. The Pacific Ocean is the biggest thing on earth.

Much of what is known of this great entity has come from Scripps' researches. The Institution has been growing rapidly during the past decade and the accumulation of knowledge has increased.

This article will be chiefly concerned with what people are talking about at Scripps at present, the zestful shoptalk of men who work close to the very limits of knowledge, but first a few paragraphs on the Institution might be useful:

Scripps began as a marine station in the early 1900's. It bears the name of two of its founders, the brilliant publisher E. W. Scripps (of the Scripps-Howard newspaper chain) and his half-sister, Ellen Browning Scripps. The Institution has been a part of the University since 1912. It is located at the northern edge of La Jolla, a pretty and quiet southern California town. Behind the shore-

1. Contribution from the Scripps Institution of Oceanography, No. 807. The author is Manager, Office of Oceanographic Publications, Scripps Institution of Oceanography.

THE UNIVERSITY *of California's Scripps Institution of Oceanography, La Jolla, Cal.*

side campus, abrupt slopes lead to a mesa covered with eucalyptus. The University owns 177 acres here, only a fraction of which is in use at present. Adjacent to the University land a group comprised principally of Scripps staff members has developed an attractive cooperative subdivision.

The Institution's mission is twofold: research and teaching. It is a graduate school, offering work leading to the M.S. and Ph.D. The oldest oceanographic institution in the country, and for many years the only one affiliated with a university, it not unsurprisingly leads all others in the number of degrees earned. Its students hold many outstanding positions in the field of oceanography. During the past few years, enrollment has averaged around 50 students a semester.

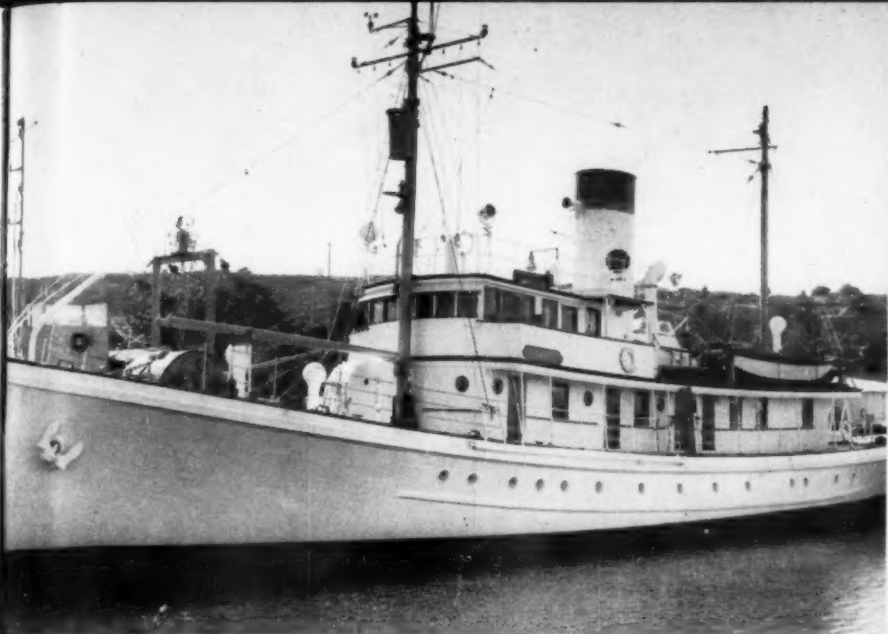
Associated with the Institution are two fisheries laboratories, the South Pacific Fishery Investigations of the U. S. Fish and Wildlife Service and the Inter-American Tropical Tuna Commission.

The campus is also headquarters of another University activity, the statewide Institute of Marine Resources, whose purpose it is to foster research and education in the development of fisheries and other resources of the sea.

Research fleet

Scripps operates the largest oceanographic research fleet in the world. This is scarcely an Armada, of course. But the five busy ships have sailed a total of approximately 400,000 miles in the past five years. Almost every month in the year at least two of them have made survey cruises over part of a pattern that extends from the Oregon border to the tip of Baja California. These cruises have been undertaken on behalf of the California Cooperative Oceanic Fisheries Investigations, a continuing study of the state's pelagic fisheries, particularly the sardine. These voyages account for about two-thirds of the miles sailed. The others have been accumulated in the course of the In-

THE Spencer F. Baird, 143-*foot former tug, is one of the five ocean-going research vessels operated by the University of California's Scripps Institution of Oceanography.*



NEWEST ADDITION *to Scripps' fleet is the* Stranger, *a yacht which was recently given to the University. She is being refitted for research.*

stitution's eight long expeditions in the Pacific. The longest of these was Capricorn, which took the *Spencer F. Baird* and *Horizon* to the fabled South Seas. Other voyages have reached Alaska, Japan, the Marshalls, Peru. Planned for the fall of 1955 is Eastropic, in the course of which Scripps scientists will again visit the northern coast of South America. These cruises have received support from the Navy.

Research staff

The research staff of the Institution numbers around 100. Non-academic employees in a variety of jobs bring the payroll to approximately 500 persons.

The research program of the Institution embraces many aspects of the sea. It can be separated into four formal divisions, but individual projects often cross these boundaries. The chief topics treated are geophysics, chemistry, geology, and biology.

Like a healthy individual, a thriving institution is less preoccupied with its past or worried over its future than engrossed in the present. New data and new concepts appear unceasingly. Here are some of the things that Scripps people are talking about today:

Edge Waves. In 1846, Sir George Stokes mathematically defined what he called "edge waves." It has thus been over a century before they could be found in nature. Walter Munk recently identified them as a source of some of the "noise" that has given him trouble on his tsunami recorder. Before leaving for Europe on his sabbatical, he completed a paper (with Frank Snodgrass and George Carrier)

ABOUT THE SIZE *of a pumpkin seed, the euphausiid forms a major item in the diet of the largest creature on earth, the whale. Scientist Betty Boden has recently extracted a new photosensitive pigment from the eyes of the euphausiids, which are part of the plankton.*

on the phenomenon and submitted it to *Science.*

Light. Brian and Betty Boden have left for the Mediterranean after a short visit to Coconut Island, Hawaii, where they made light measurements. Mrs. Boden has recently published in *Nature* on the discovery of a new photosensitive pigment, euphausiopsin, in the eyes of euphausiids. Her husband's work on the euphausiids of the Pacific (done with Martin Johnson and Ed Brinton) is scheduled for publication by the University of California Press late this fall.

Heat Flow. For several years now, a number of people among whom are Roger Revelle, Scripps' director, and Sir Edward Bullard of the National Physical Laboratory, Teddington, England, have been measuring heat flow through the ocean floor. About 25 measurements have been made in the Pacific. The warmest spot yet found lies on the Albatross Rise to the west of South America. A long paper summarizing the heat-flow work has been accepted as a Memoir of the Geological Society of America.

Flamingos. As zoo keepers long have known, you can brighten up your flamingos by feeding them ground-up shellfish in addition to their usual diet of grass pellets, millet, rice, and dried flies. Denis Fox is interested in the biochemistry of the process and has been studying flamingos at the San Diego zoo. Some

of the red pigment, astaxanthin, eaten by the flamingo reaches the skin and feathers, but most of it is broken down in its passage through the bird's body. Fox reported on his work at the Biochemical Congress in Brussels this summer and has published in *Nature* on it.

Lateral Line. For several months last year physiologist Ted Walker engaged in a duel of wits with a small sea perch, *Cymatogaster aggregata* Gibbons. For quite a long time, *Cymatogaster* won every round. Walker is working on the lateral line of fishes. To study the response of the perch to pressure vibrations in the water he designed an experiment that was simple in principle, but, thanks to the sea perch's acuity, remarkably hard to carry out. Essentially, he hoped to train the fish to recognize that a pressure signal of a specific frequency would mean it would find food in a specific place. But first the fish watched the food being introduced into the tank through transparent glass tubes. Walker painted the tubes black. The fish then watched the oscillation of a pressure bubble in the manometer. That was masked. *Cymatogaster* possesses monocular vision, that is, his eyes can work independently. Walker was working with two dishes. The fish focused an eye on each dish. "I

THIS FISH *wears a bathing cap. Theodore Walker fashioned the latex cap in the course of his studies of the lateral-line system.*

felt at times that the fish should have kept the notebook," Walker said. At one point in the research, Walker fashioned latex "bathing caps" to decrease the sensitivity of the lateral line around the head. When the fish had apparently learned to respond as desired to the appropriate signals, Walker found it was actually cueing to the difference in vibration coming from the pressure-actuating motor rather than pressure itself. These behavioral studies have been combined with investigations of the structure of the lateral line system.

Underground Oceanography. Doak Cox came over from Hawaii last fall to spend some time working on "underground oceanography." Cox has been studying the movement of ocean water that seeps through the permeable Hawaiian rock to underlie the water table of fresh water. His data come from the wells which water the lush Hawaiian plantations.

Oceanic Fronts. The ocean has well-defined boundary zones between cool and warm water which by analogy with meteorological practice Townsend Cromwell has called "fronts," a word that meteorologists, by the way, again from analogy adopted from the alien science of warfare. Cromwell and Joe Reid have submitted a paper to *Tellus* dealing with two such clearly marked boundary zones in the tropical Pacific.

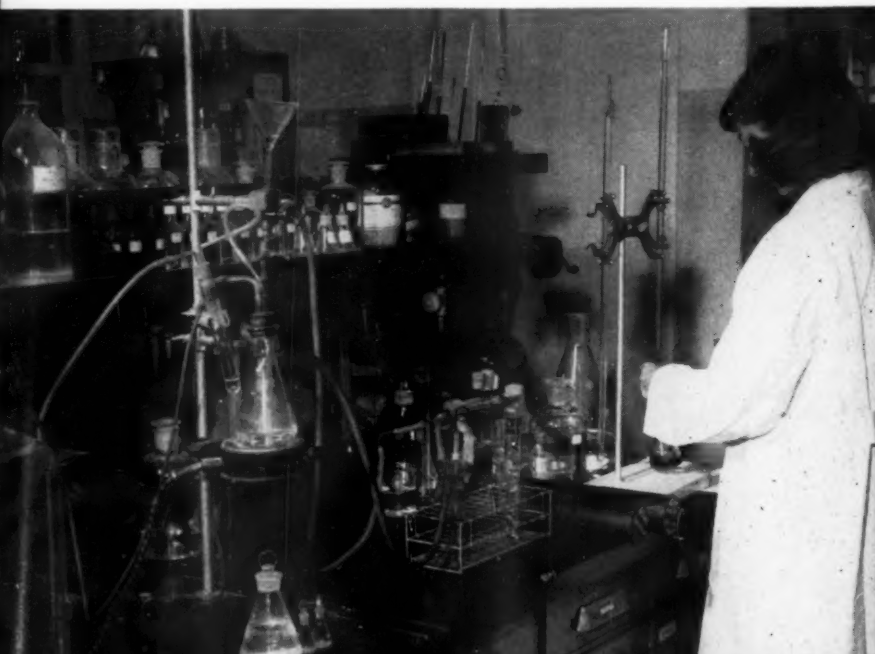
WILLARD N. BASCOM, *research engineer, aboard the* Spencer F. Baird *on Capricorn Expedition of the University of California's Scripps Institution of Oceanography, caught by a sudden breaking wave.*

Sewage. What to do with sewage is one topic under frequent discussion. California is paying the penalty for its explosive growth during the past decade. One of the many problems presented by its enormous new population is that of sewage and the cities are turning to Scripps for advice. That is particularly true of San Diego, a municipality whose bay is already seriously contaminated. The prescription of the engineers has been a sewage treatment plant whose cost is estimated between 16 and 30 million dollars. Scripps staff members have been called upon for advice and it is possible that the Institute of Marine Resources will establish a long-term project dealing with the subject.

Detergents. Carl Oppenheimer, who spent the spring in Norway—his second visit there—has found that one part per million of some common household detergents is lethal to marine perches in laboratory aquaria. The substance does not poison the fish, but so affects the gills that the creature suffocates. Whether the stuff is as deadly in nature as in the laboratory remains to be determined.

Middens. Indefatigable Carl Hubbs has received support from the National Science Foundation for one of his projects, the determination of climatic conditions along the Pacific coast in the past. For evidence, Hubbs depends upon kitchen middens, prehistoric rubbish heaps in which have been found charcoal and shells. Charcoal (carbon 14) dates the heaps, the shells (oxygen 18) give the oceanic temperatures from which terrestrial climates can be to some degree extrapolated. Hubbs finds several periods in which the climate differed from that of today, with corresponding dif-

A VIEW *of one of the microbiology laboratories of the University of California's Scripps Institution of Oceanography.*



ferences in fauna and in the size of the human population. Today's bleakly barren Baja California coast has in the past supported thriving Indian populations, he finds. Hubbs' work with isotopes may be given further impetus with the prospective appointment of Hans Suess and Harmon Craig to the Institution's staff.

Diving. Scripps remains the only campus of the University at which the official use of self-contained underwater breathing apparatus is allowed. The Institute of Marine Resources' Acting Director Admiral Charles Wheelock, Conrad Limbaugh, and others have spent several months framing a policy for use of the equipment. Their work is being closely followed by other agencies which have found the gear valuable in research.

Sardines. The news on sardines, in the study of which Scripps has joined four other research groups, is that the 1954-55 season's catch, while puny by the standards of the flush 1930's, was about 20 times the size of that of the previous season. The sardines came back in 1954 to spawn widely off southern California and 67,000 tons were caught during the fall. Spawning has again been widespread in the same area during the spring of 1955, but comparative figures for the two years are not yet available.

Rockefeller Grant. Last year the Rockefeller Foundation gave the University a million dollars to support expanded research in marine biology at Scripps over a period of years. A La Jolla committee headed by Adriano Buzzati-Traverso, is planning the use of these funds. Scheduled for the spring of 1956 is an international symposium on marine biological research.

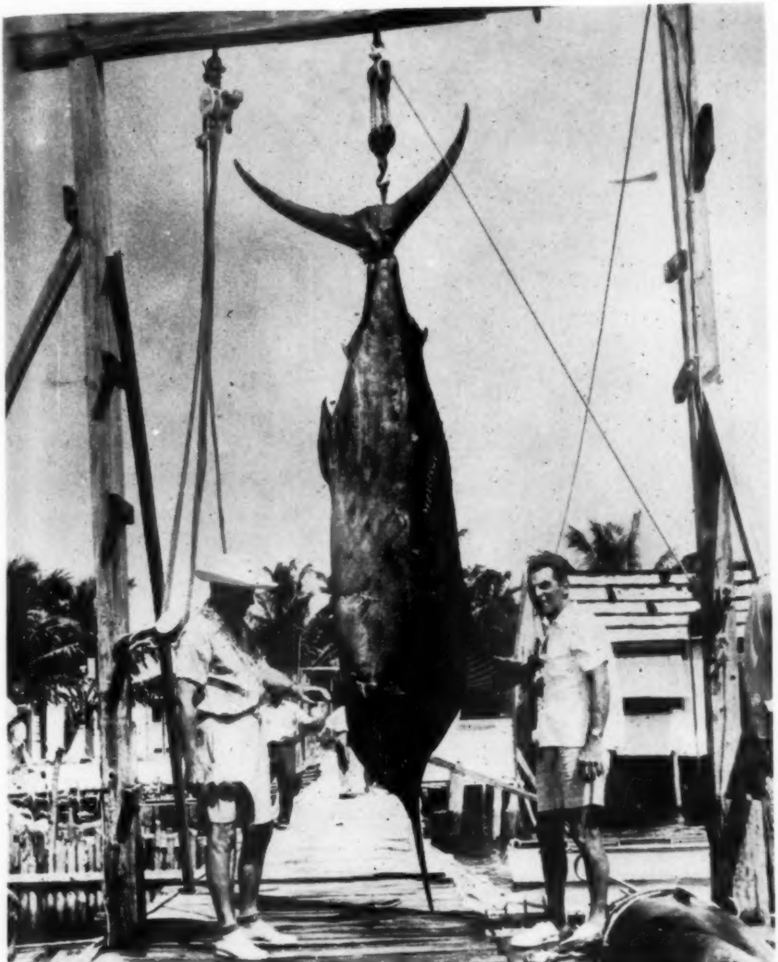
These few examples may illustrate the breadth of Scripps program. They also emphasize the essential continuity of Scripps' half century of study of the great Pacific.

Feeding Marlin Uses its Head

THE PRECISE WAYS in which the various species of billfishes are accustomed to make use of their bills in capturing food has often been debated and even experienced anglers will not always agree on the subject. In the case of the marlin, it has been held by some that the bill can be used for spearing its prey. Whether this is a common habit or not, it has been definitely shown to happen in the case of one marlin in the Pacific recently.

On a recent cruise of the U.S. Fish and Wildlife Service longline vessel *John R. Manning* in the yellowfin tuna grounds near the Equator, south of Hawaii, the capture of a huge "white marlin" was reported. Its weight was estimated as around 1500 pounds, and in its stomach was a newly killed 5 foot long yellowfin tuna weighing 157 pounds. Of especial interest was the fact that the tuna had been swallowed head first and that it had been speared twice completely through the body.

The "white marlin" of Hawaii and Japan *(Makaira marlina)* is known as black marlin in Australasia and off the Pacific coast of South America and is, of course, distinct from the Atlantic white marlin *(Makaira albi-*



THE BLUE MARLIN. *This particular specimen weighs nearly 750 lbs. and is still the Atlantic Ocean record for any tackle. It was caught off Cat Cay, Bahamas, by Axel Wichfeld, who is on the left, together with Captain Eddie Moore, veteran marlin guide.*

da). To add to this slight confusion, in Japan and Hawaii the term black marlin is given to what is believed by some to be the same as the Atlantic Blue Marlin *(Makaira ampla).* This in turn may be what is known in the eastern Pacific as the silver marlin. It is nonetheless interesting to know that the Hawaiian "white marlin" spears its prey, no matter what its true name.

A Clean Hull and a Fast One

THE PRICE PAID for a foul hull may be measured in many ways, but whatever the measure the cost comes high. A hull covered with barnacles, grasslike algae or soft bodied sea creatures loses a surprisingly high proportion of its speed due to increased water friction. This may mean increased duration of the passage of a commercial vessel, with increased fuel costs; or it may mean the failure of a naval vessel to keep station in a convoy or to make a vital rendezvous; even a small amount of fouling may make the difference between winning and losing an ocean race; or, in order to keep down fouling, there may be shorter times between hauling and painting, with resulting loss of time and added expense.

Ancient formulas

The efforts of modern scientific research have done much to solve the problem of fouling prevention, especially in recent years. The perfect solution has not yet been found, but we have progressed a long way since the ancient Phoenicians and Egyptians tried to find an answer. As in medicine, antifouling devices of the past had a flavor of witchcraft in them. Every conceivable kind of poison, horsehair, cowdung and even fish oil, suet and lime appear in the earlier formulas for coating ships' bottoms.

The last century saw some progress, but much of it was by hit and miss methods, an empirical mixing together of likely and unlikely materials that came to hand. By 1865 over 300 patents had been issued in England alone for antifouling paints, containing everything from kitchen salt to iron rust. Admiral Sir Edward Belcher reported that most of them seemed better fitted to encourage rather than to prevent fouling. In fact it was said that some of his sailors were paid as much as ten shillings for the unusually fine specimens of sea life and shells which flourished on the *Ardent*.

Erratic paints

Even today, when chemists and biologists have applied careful scientific method to the development of good antifouling paints, the shipowner and yachtsman is bewildered by conflicting experiences and by the apparently irrational behaviour of these coatings. Naturally he would like to know why this is so. Why do similar vessels, using the same paint, behave so differently with regard to fouling, sometimes even when they have adjacent moorings or berths? Why does the same hull treatment give good protection at one time and place and a mediocre performance at others? These are questions that may be answered against a background of scientific understanding of the nature of fouling and of the way in which a good antifouling paint performs its function.

There is a quite surprising number of species of marine plants and animals which find a ships' bottom convenient and suitable for attachment, and these vary quite considerably in their distribution. On the whole, though, they behave in the same general manner. Barnacles and algae, more often called moss or grass, be-

have similarly by setting free in the seawater tiny young stages which are called larvae in the case of barnacles, spores or zooids in the case of algae. These drift independently in the water. The length of life of larvae is definitely limited. If a suitable surface for attachment is not found within a certain number of days the larvae die. So, the amount of fouling which could occur at any place depends upon the amount of larvae which are normally

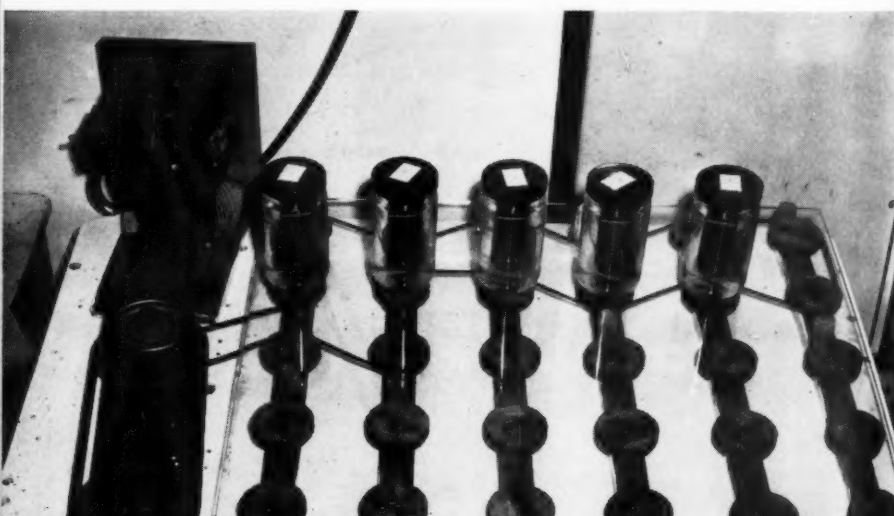
THE HEAVY GROWTH *of marine life on the bottom of this ship adds greatly to fuel costs.*

released in that area. On the high seas, since there are no concentrations of the adult fouling creatures, there are virtually no larvae and so the fouling potential is almost zero. In heavily fouled harbors with conditions such as salinity and temperature favorable to the larvae, the fouling potential will be high. Where there is a high admixture of fresh river water in the harbor or where industrial pollution is severe, the fouling potential may be low. In high latitudes the cold winters restrict the breeding of sealife and the release of larvae to a few warm months. In the tropics the period of heavy fouling potential may extend over the entire year.

This variation of fouling potential explains why, when using an inefficient paint, bottom fouling may vary from nothing to very heavy, according to time and place. Moreover, since some attached sea life is able to withstand pollution or freshwater better than others, not only the amount but also the kind of fouling will vary according to the principal mooring places of the ship. A further factor has been brought out as a result of scientific study. Barnacle larvae, and probably most others, cannot attach to surfaces if the water is flowing past them at a speed greater than about 1 knot. Thus, a ship which spends most of its time under way or one moored in a fast tide stream is less subject to fouling than a yacht or fishing cruiser which is tied up most of the week and only used at weekends.

What's in the paint?

The question is further complicated by the nature of the antifouling paint and the way it works to prevent fouling. Essentially the paint is made of a poisonous material, the toxic, which is mixed with the basic ingredients of the paint film, called the matrix, together with a liquid solvent. The



APPARATUS *at the University of Miami used for rapid testing of the efficiency of anti-fouling paints.*

toxic usually consists of red cuprous oxide, though other copper and mercury compounds may also be used. The antifouling action of the paint is known to depend upon the rate at which the toxic goes into a poisonous solution at the surface of the paint as a result of the solvent action of seawater.

Cuprous oxide dissolves more easily as the temperature of the water increases. It also dissolves less easily as the water becomes less salt, as it may do in estuaries which have much freshwater. For this reason the rate of solution of the copper will vary from place to place and from time to time. If it drops too low the paint will be less effective in controlling fouling. On the other hand, if the copper dissolves too rapidly, the entire amount might be lost and the paint become ineffective after a short time.

How the paint works

A further problem in making antifouling paints which explains the very erratic behaviour of some of them, is the effect which the matrix has on solution of the toxic. In one type of paint, in which soft resins are used, the resin dissolves as fast as the toxic, so that new particles are being continuously exposed during the life of the paint film. If the matrix dissolves too slowly or the toxic too quickly, the paint will at first release the toxic exposed at the surface but then it will become ineffective until gradual solution of the matrix exposes new toxic particles to the action of seawater. In another type of paint, the matrix forms a thin, tough, almost insoluble film, but the toxic is present in such large quantities that there is almost continuous contact between the particles. Thus, when particles of toxic at the surface are dissolved, they expose those beneath the surface and in contact with them. Eventually, when the paint film has reached the end of its useful life, it is still a strong film, but inside it is a series of holes like those in a Swiss cheese, where the toxic formerly existed.

What paint to use

A fast ship in continuous use will tend to dissolve the toxic more rapidly and so have perfect protection but for a shorter period. Unless the *complexity* of the paint is taken into account, together with the *complexities* of the fouling organisms, it will be seen that it is difficult to compare the relative values of different paints. Altogether, then, a poor antifouling paint may make a good showing under certain harbor conditions, or with certain types of ship service, but under others it will foul rapidly. Even a good antifouling paint may have its useful life increased or decreased by the conditions under which it is used.

For a ship which is to be hauled frequently, whether it needs bottom paint or not, it does not pay to use a very expensive paint, since the cost of paint is a small part of the total cost of hauling, scraping and painting. When it is desirable to keep a ship in the water as long as possible and when it will see service in waters fouled heavily throughout the year, the very best paint is indicated, no matter how expensive. Fortunately the work carried out at marine research institutions has now made it possible to design a paint with a service life of over a year under almost any conditions—provided it is not scraped off by going aground or minor collisions.

Opening the Door to Discovery

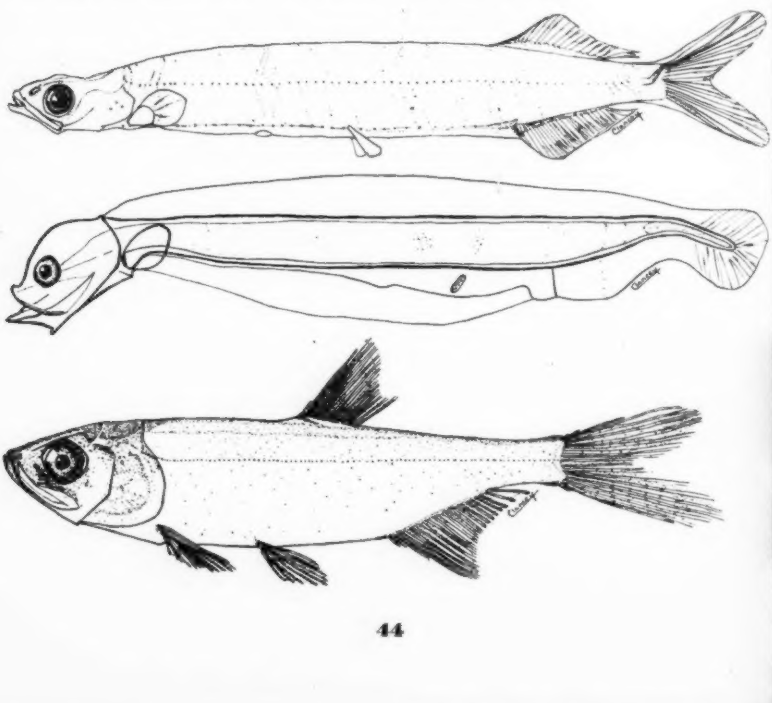
THE GRANTS AND AWARDS COMMITTEE of the Foundation during its first active year has recommended grants in support of two widely different objectives of marine research. One of these, dealing with tarpon research, has already made considerable progress in a study of this superlative game fish, while the other has just begun work on an interesting and unusual study of the sea-floor.

Tarpon research

The Tarpon Research Fund was originated with a donation from Mr. Roger S. Firestone, as reported in the last number of the Bulletin. For the past several months this has been used to support the investigations of Mr. Robert Ellis and Mr. Alfred Volpe, and is supplemented by funds of the Florida State Board of Conservation. The program of research includes tagging of fish, in order to obtain knowledge about growth rate and migration; measurements of fish and study of scales and stomachs for information on growth and feeding habits; and a study of plankton and fertilized eggs for information on life history and the pattern of movement and distribution during the larval and juvenile periods of development.

During the month of June a num-

THREE STAGES *of development of the tarpon, the leptocephalus, or ribbon-like larva, the preleptocephalus, and the juvenile. The largest of these is 1½ inches in length.*



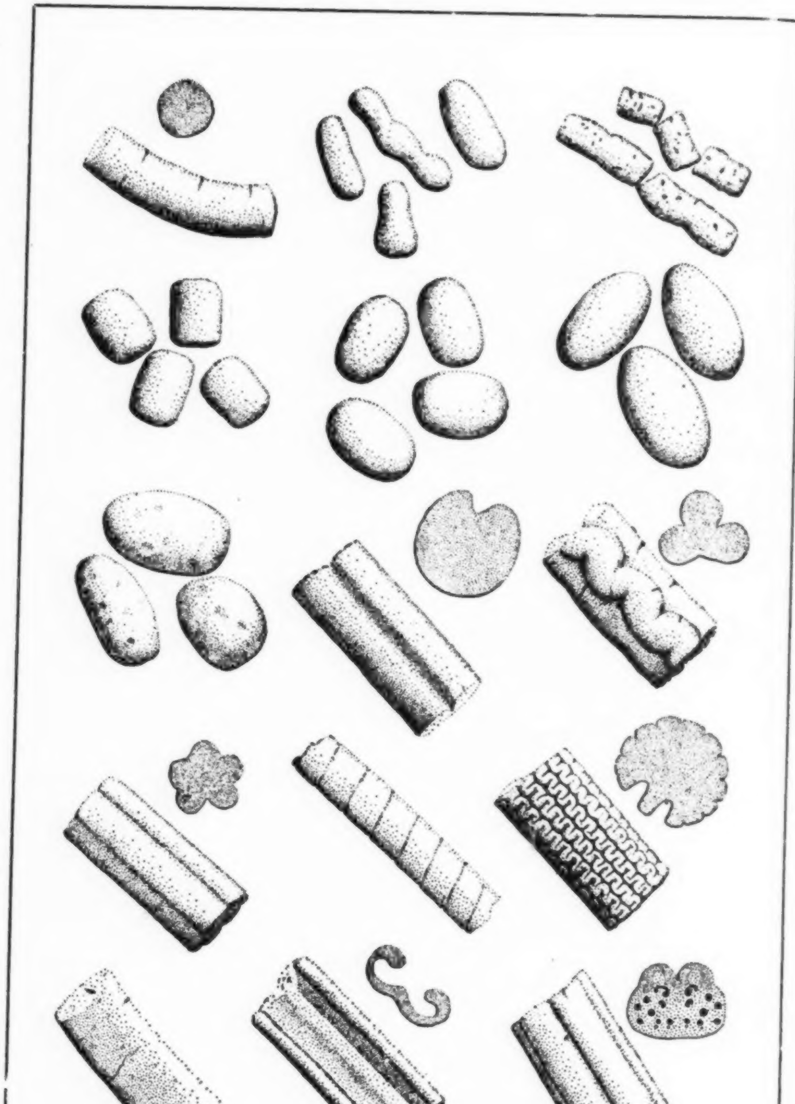
ber of schools of tarpon were studied, which were "milling" or moving in a circle. In each case fine meshed plankton nets were towed through the schools, which were believed to be spawning. As a result, a supply of fertilized eggs was obtained. A number of these eggs hatched out into larvae and their further growth was observed under microscopes in the laboratory. In order to obtain later stages of development, plankton nets were also towed both inshore and offshore during each month and specimens were taken which are believed to be further stages of development of the tarpon. These stages are ribbonlike in form and are quite unlike either the early larvae or the adult. Thus a beginning has been made in tracing the life history of this fish.

So far it seems that the tarpon breeds in the brackish waters during the early summer months. During the cooler months of the year they are not so noticeably abundant inshore and are probably more widely dispersed. As the temperature rises they begin to school inshore, first of all in the more southerly warmer waters and then progressively towards the northern end of their range.

These studies have been made principally in the Boca Grande, Florida, area, a particularly favorable one. Nevertheless, although only abundant in the warmer waters, tarpon are at times found on the Atlantic coasts all the way from Nova Scotia to Argentina. In Florida, considerable assistance has been given by anglers and fishermen and also by Dr. Eugenia Clarke of Cape Haze, Florida. Mr. Gilbert Voss, who is in charge of these investigations, wishes to express his gratitude for such help and to invite the fullest participation of all tarpon fishermen in the future in this search for information.

UNIVERSITY OF MIAMI *scientists tag a tarpon off the west coast of Florida.*

MR. ROBERT ELLIS *and assistant Mr. Alfred Volpe examine scales of tarpon as part of their study of growth rate.*



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Fingerprinting Ancient Sea Floors

The Shell Development Company, one of the first industrial associates of the Foundation, has contributed funds which are being used to aid Mr. Paul Kruse in his study of sea floor sediments in the shallow waters of the Florida Keys and the Gulf of Mexico. Kruse hopes that the results of his study may provide new information to aid in the identification of the rock strata which are the petrified remains of ancient sea beds in the remote geological past when the oceans sent tongues of water deep into the North American continent.

At first glance the seafloor might seem rather barren, except where seaweeds or corals grow. On closer examination though it is seen that the muds and sands contain a teeming population of worms, clams, snails and other forms of marine life. Many of these creatures consume prodigious quantities of mud and sand in order to extract the organic remains which are found there. The resulting large amount of undigested material is deposited by these animals, after passing through their digestive canals, in the form of sandy or muddy pellets, known as fecal pellets or coprolites. These pellets may later, as part of the sediments of the seafloor, act as evidence of the presence of the animals from which they came. Some of the pellets are soft and easily broken apart, but others are firm and have a well defined form, distinctive of the animal which formed them. Thus, when turned into stone, they are like fingerprints to the geological detective. Some are spherical, some rod shaped and of various lengths. Many are marked with characteristic lines, pits or notches. The work of Paul Kruse is to set up at the University of Miami a kind of identification bureau based upon these telltale pieces of evidence, of immediate value to science as another tool for the study of animal relationships in the present day seas. Less directly it may also help the oil geologist to know what type of ancient sea bed his exploratory drill has penetrated.

ASSORTED COPROLITES. *These pellets are the faeces of marine animals and are highly individual in shape and form. Thus they provide a means for identification of the creatures which inhabited ancient seas. Those pictured here were dropped onto the seafloor by limpets, sea cucumbers, clams, mussels and various crustaceans.*

MR. LANSING WAGNER *works up the data of a typical oceanographic cruise. For every day at sea there are many days of work on shore whereby scientific conclusions are drawn from the results by careful calculations, graphs and charts and by chemical and biological analysis.*

Measuring the Ocean

By LANSING WAGNER
The Marine Laboratory, University of Miami

AS ANYONE KNOWS who has organized an expedition, no matter how short it is, one goes through some moments of sharp anxiety and some longer periods of general worry before the last piece of equipment is stowed and the time of departure has arrived. It is also true that few oceanographic investigations at sea come off exactly as planned. Wind and sea do not always cooperate and weather which is fine for ordinary passages may be just rough enough to make instrument observations at sea difficult and uncomfortable or even dangerous. Such were the feelings of some members of The Marine Laboratory towards the end of March, 1954, when preparations for an exploratory oceanographic cruise in the Cayman Sea were being made.

For several years this particular group had been measuring the horizontal and vertical pattern of temperatures and the currents in the Gulf Stream off Miami, which on nautical charts is called the Florida Current. Curious fluctuations in the current and temperature patterns had been noted but their cause remained unsolved. Few modern measurements had been made in the region where this current seems to make up, generally in the Caribbean Sea and perhaps more specifically in the Cayman Sea. Earlier work by other investigators has shown that in general the Gulf Stream System is caused by the

push or pull of the constant Trade Winds in the lower latitudes and of the Westerlies in the higher latitudes and its path and shape influenced by the rotation of the earth. Since a fast flowing, well defined current east of the Bahamas has not yet been recorded, it is widely believed that most of the surface water "pushed" westerly by the Trades from the Equatorial Atlantic slowly flows through the passages in the Lesser Antilles region and to some extent through the Mona and Windward Passages. At some point within the Caribbean, this sheet of slowly moving water comes together to form a narrow, fast moving current such as is observed off the coast of Havana and Miami, and presumed to exist between the Western tip of Cuba and Yucatan. Where is this point? Why does it exist? Does it change position and if so, why, and does such a change produce the fluctuations observed further downstream in the Florida Straits? All of these problems could not be answered in one trip, no matter how extensive.

Planning the cruise

Taking all this into consideration, a cruise was planned with the idea of repeating parts of it in the future, depending upon the results of the first trip. The actual work would start near Key West, from whence a series of observations would continue to a point off Havana. Next would come a probing series of observations from the northwestern tip of Cuba to the northwest, followed by another series to Grand Cayman island by way of the Isle of Pines. From that harbor the plan called for a crossing of the Cayman Sea to the coast of the Republic of Honduras, passing close to the small American observation post of Swan Island. Then on to Belize, British Honduras, for refueling, water and a few supplies. After a short rest, the vessel would head northeast to relocate the current, if it existed, and follow it through the Yucatan Channel, and then head for Havana and Key West. It was considered by all to be a very adequate plan and one which could be accomplished in about 18 days.

While the scientific crew, headed by Dr. Ilmo Hela, made plans and stowed away the necessary gear, Captain Kou Walter made ready the research vessel *Physalia*. This vessel is a converted eighty-three foot Coast Guard craft, with a cruising speed of 9 or 10 knots, powered by twin GM diesels. It is equipped with necessary winches for hydrographic work. A small laboratory in the upper cabin houses a fathometer, Nansen water bottles, geomagnetic electokinetograph sound recording equipment and a radio. These would be the main tools of the investigation. This, of course, sounds very simple, but a glance at the check list of the scientific material required for such a cruise will show how even a simple expedition calls for detailed staffwork.

A Seagoing check-off list

Hydrographic Station equipment.

- 14 Nansen water bottles and storage rack
- 20 Reversing thermometers and calibrations
- 15 Messengers
- Hydro station logs
- Hydro wire and meter wheel
- Hydro winch
- Angle meter
- Secchi disc
- 500 Salinity sample bottles
- Oxygen drawing and determination equipment

Bathythermograph Equipment

3, 900 ft. bathythermographs
1, 450 ft. bathythermograph
500 Smoked slides
Calibration grids and grid viewers
Smoked slide fixing equipment
2 2,000 ft. reels stainless steel 3/32″ wire
Bathythermograph winch and boom installation
3 Sheaves
Hardwood guide sticks
Temperature—depth profile paper
Surface thermometers and containers
Sling psychrometer

Geomagnetic Electrokinetograph Equipment

Instrument and installation
2 Cables and electrodes
Spare parts for instrument
GEK logs
Current component plotting board
Acoustic and sound recording gear

General Equipment

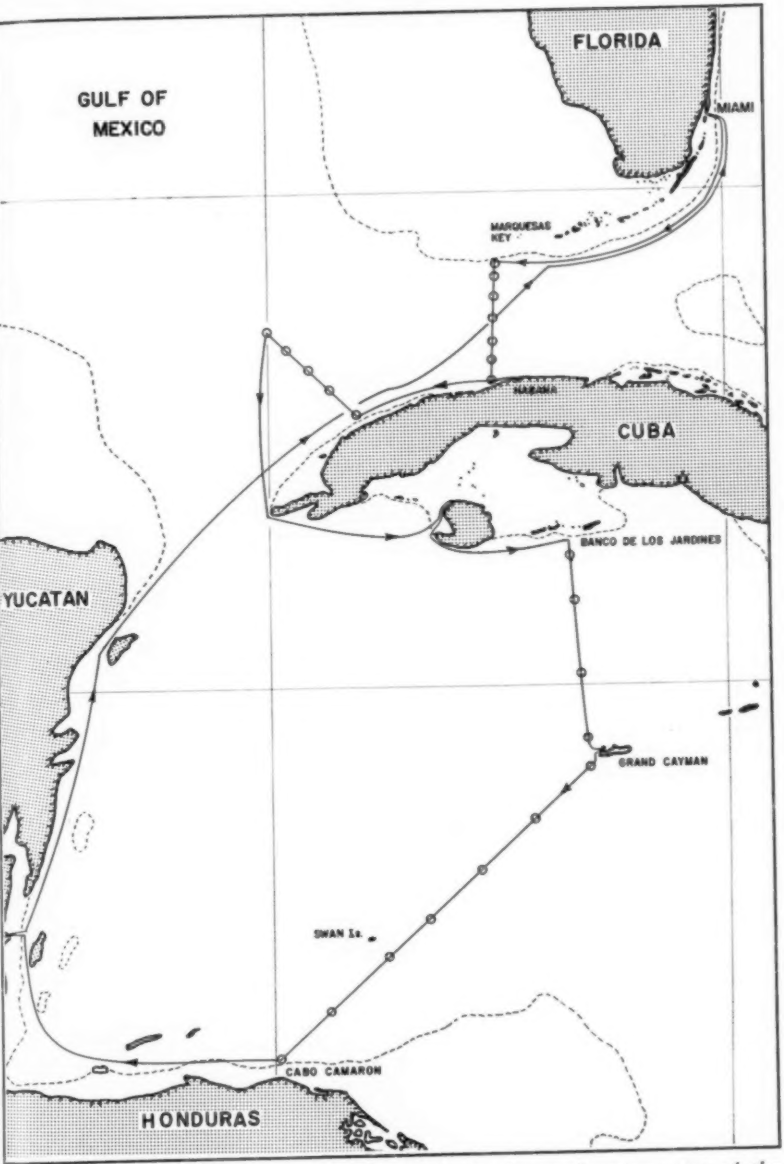
Charts; navigation, plotting Loran
Fathometer and spare parts
Loran and spare parts and logs
Radio and spare parts

General Supplies

Log books
Pencils and other plotting aids
Tools
Rope and marlin, camera, nets

The first leg of the cruise was to be a transect between Key West and Havana, work starting on the shallow shelf off the Marquesas Keys. The plan was to make eight hydrographic stations on this crossing spaced in such a way as to be at right angles to the current. In between these stations underway measurements by B.T. and G.E.K. would be made.

A hydrographic station is a place where the oceanographer takes samples of the water below him. The vessel is stopped, and a 7/32″ stranded wire cable is let overboard weighted down by a lead weight. Onto this cable are attached the reversing Nansen bottles holding reversing thermometers. The steel bottles are used for taking samples of the water and the thermometer for taking the temperature accurately at various depths. Eight to ten bottles are attached to the wire at varying intervals, depending on the approximately known nature of that particular column of water and upon the wire angle or slant of the cable expected. When the cast is down and sufficient time has been allowed to let the water in place flush through the bottles and bring the thermometers to a steady reading, a weight or "messenger" is slipped over the wire and allowed to drop. On striking the first bottle this releases a catch and permits the bottle to swing through a 180 degree turn. A special mechanism is thereby made to close the two valves at top and bottom and so trap a sample of water. At the same time this happens the mercury column in the reversing thermometers breaks, the amount trapped by this depending on the temperature of the water at that position. The swinging movement of the bottle also releases a "messenger" attached below it, which in turn will fall along the cable and trip the bottle below. In this way samples of water with temperatures *in situ* at the required depths are obtained. In depths to 300 fathoms one cast is usually enough, but greater depths call for a second cast so that



THE COURSE *of a typical oceanographic cruise in the northwestern part of the Caribbean Sea. During the course of this cruise hydrographic sections, samples of seawater and measurements of temperature at various depths were taken at the places marked by circles.*

sampling levels are not too far apart. Back on deck, the water samples are drawn off into glass bottles and the thermometers are read and recorded.

In between these stations underway measurements were made by the bathythermograph or B.T. This is a torpedo-shaped instrument that continuously records temperatures and depths down to 900 feet. The record is scratched on a small smoked glass slide as the pressure and the temperature recording elements move. The B.T. is at the end of a 3/32″ stainless steel cable and a winch is used to retrieve it. Before or after this is done, a surface current measurement is made by means of the geomagnetic electrokinetograph or, more simply, the G.E.K. This is a recording instrument which measures the small electric potential produced whenever a salt water current flows across the magnetic field of the earth. Since the electrical measurement is proportional to the water current, this makes a convenient way for quick detection of ocean currents. To do this, a two lead insulated cable with electrodes is towed by the vessel. The cable leads into the G.E.K., which in turn magnifies and records the signal or amount of electricity. Since this only measures the amount of current flowing to port or to starboard, a second reading has to be made at right angles to the main course of the ship. In this way, two components of the current are obtained, and when the two are added together the total velocity and direction of the current is approximated.

Man overboard

Work progressed well and uneventfully until a passing freighter from West Germany was sighted. At this point a member of the freighter's crew decided to desert ship and plunged overboard. The freighter continued while the *Physalia* was hove to in order to haul in the sailor. Then, after some delay, the Coast Guard was finally reached by radio, whereupon the freighter changed course and steamed towards their missing man. He was met with gutteral threats and we with surly glances and no thanks. Shortly after this delay, further trouble set in. The deep freeze ceased to operate. Since we were close to port this gave a welcome opportunity to stop at Havana.

Shark eats electrode

The cruise continued and the leg northwest of northwest Cuba was made. After seventy-five miles on this course the members were satisfied that at this time, at any rate, there was no current racing around the western tip of Cuba, as had been reported. The course was changed to south and another series of observations was started. The recording pen on the G.E.K. suddenly went wild, which could only indicate that the trailing cable had tempted a shark or barracuda. The vessel was stopped and the cable pulled in. The weather was rough and dark and rainy and not at all the best time to make instrument repairs. In the feeble light of the rear lantern the cable was tested for lacerations by running bare hands along 150 meters of its insulation. At last the spot was found, washed in fresh water, dried and taped up, and with some mutterings against all fish the cable was tossed back into the water. Measurements would be continued . . . with luck.

As both ship and scientific crew were small, there could be little rest day or night for anyone during operations, so that rather frequent resting places were necessary. After a series

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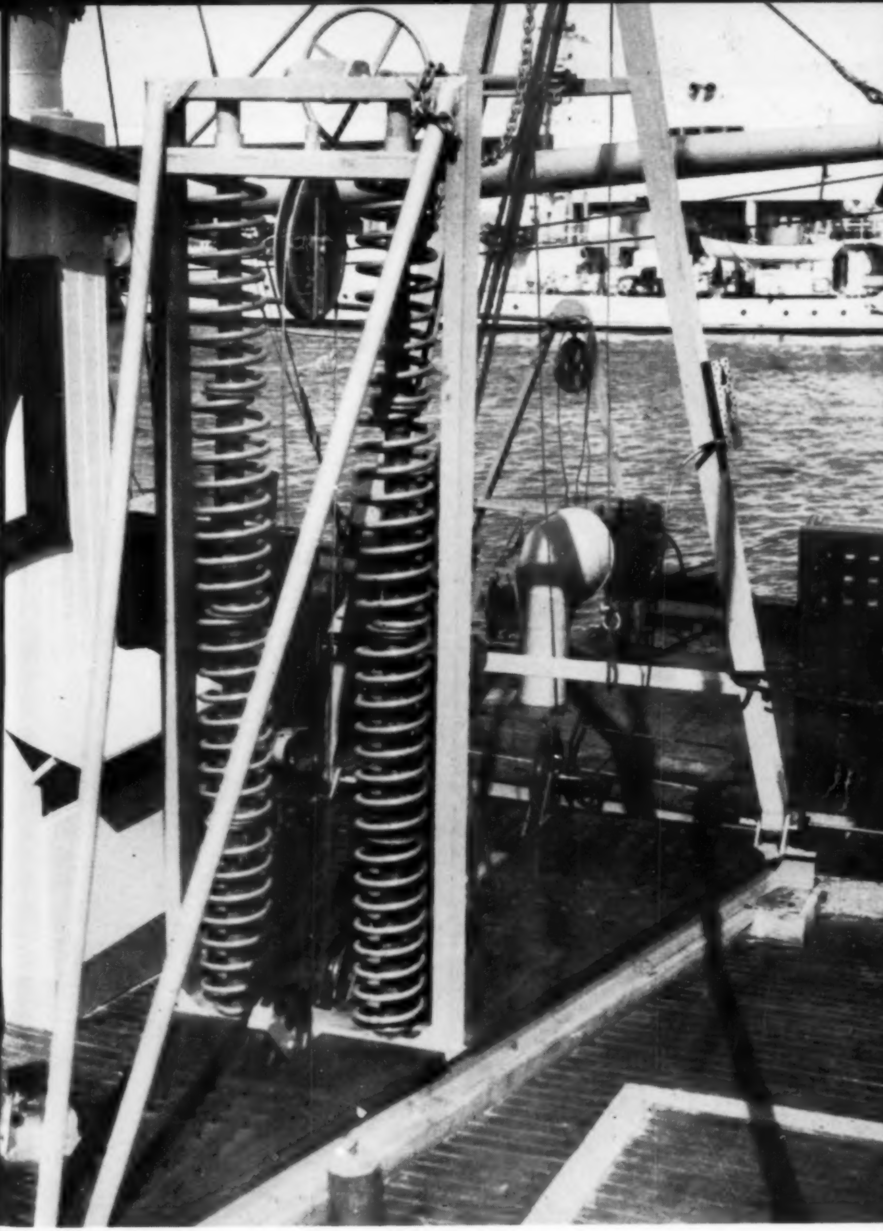


THE LARGE COIL SPRINGS *are designed to ease the strains and shocks to which the instrument cable is subjected as the ship rolls in a heavy sea.*

of measurements along the southwestern coast of Cuba, which showed weak currents with westerly directions, the vessel was anchored near the closest port, Nueva Gerona. This is the only port on the Isle of Pines and is situated on the north side of the island in the lee of a small mountain range. Those who were not too tired went up the narrow river by means of skiff and outboard in search of grapefruit and other refreshments. The grapefruit is the chief specialty of the island and on leaving the small dock the harbor master very generously had the skiff filled with a supply. These were to come in very handy during the next two weeks for water storage is small on the *Physalia.*

Isle of Pines to Grand Cayman

Continuing the cruise plan, the transect from the Isle of Pines to Grand Cayman Island was completed. There several fishermen were questioned as to the nature of the currents near the southwest of the island. They thought there was a slight circular movement around the island (counterclockwise). During fishing and turtling trips to the coast of Honduras they always allowed for a northwesterly set about seventy-five miles east of Swan Island. The next transect was long but calm and the results were interesting. The main branch of the Caribbean Current crossed this transect northwest of Swan Island and probably south of the Mysteriosa Bank. The direction of the current was towards 280° with a velocity slightly above one knot. Another relatively strong current had been measured closer to Grand Cayman flowing with a more northerly component. The measurements from the hydrographic stations were in good agreement with these findings. However, the temperature and velocity structure in this region were very dissimilar to those of the water between Key West and Havana. This could mean that along the Grand Cayman-Honduras line, or further east, water is starting to flow together to produce a stream. It was therefore planned that future work should be carried on further upstream, perhaps between Jamaica and the shallow banks off Honduras.

Cable hits bottom

The last station on this transect was made within sight of the Honduras mountains behind Cape Camaron. Making a hydrographic station in rapidly shoaling water is always risky if the bottom Nansen bottle is as close to the bottom as it should be. The vessel was hove to when the fathometer started recording one hundred fathoms. The last station was under way. Everything went smoothly and all hands felt relieved, since this would be the last station until after a rest in Belize. When the last bottle was signalled to appear at the surface several pairs of eyes strained to see it. Only the clamp remained screwed onto the wire with the lead weight dangling 20 ft. beneath. The bottom had shoaled more rapidly than expected and the last bottle had dragged on the bottom, finally tearing itself loose on a rock.

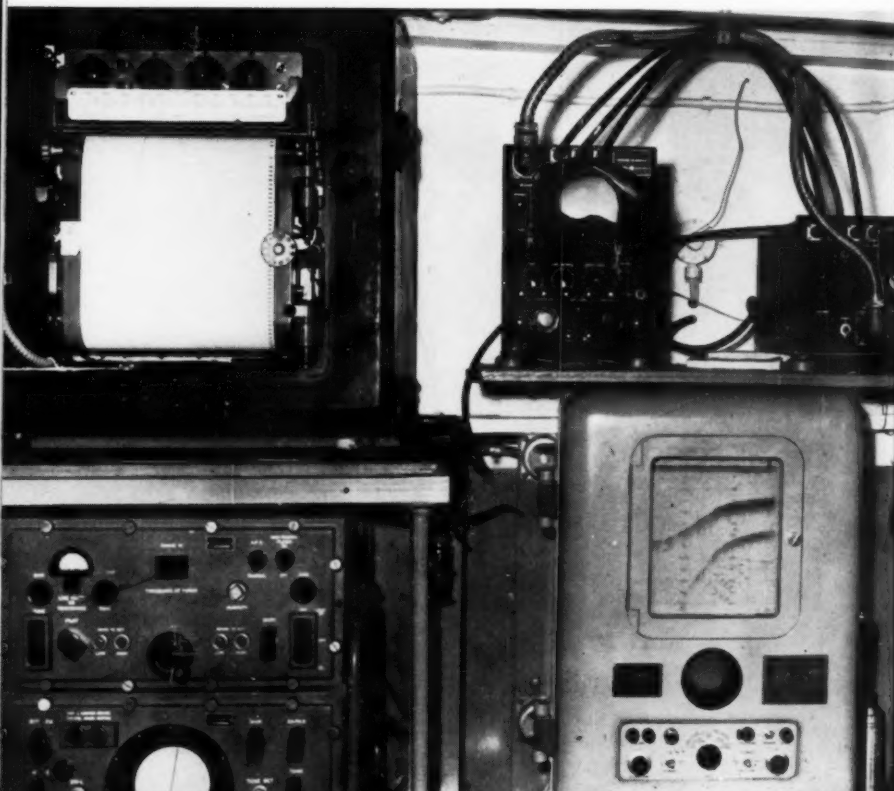
After taking care of this last difficulty, the vessel steamed west along the coast of Honduras and passed Isla de Roatan, heading for Belize in British Honduras. Although tired out, the party could not help noticing that the wooded keys and great reefs are very beautiful. In Belize the captain arranged for the loading of fuel, water and some food. Some of the members took the opportunity to visit the remains of an Inca temple some eighty

PLANKTON NET *being hauled to the surface during an oceanographic cruise. The movement of net and cable is signalled to the winchman by the scientific assistant standing on an outboard grating.*

miles in the hinterland. A visit was also made to a mahogany forest and mill and members of the cruise returned with many fine rough boards which were a gift from the owner. It was noticed with some surprise that the small chicken coops in the city were made with scrap mahogany—the cheapest wood available.

On leaving Belize, bad weather set in with a cold front which was reaching that far south. The cruise plan called for a transect to the northeast in order to relocate the current and then to follow it to the Yucatan Channel. The high winds and heavy seas unfortunately strained the hull. The resulting leakage of the *Physalia* made it necessary to modify original plans and the next best solution was to steam north to Cozumel and then to make a series of stations across the Yucatan Channel to Cape San Antonio, Cuba. As we passed Cozumel and headed northeast on the new plan, the seas were even higher and more water was coming in. Already everyone had turned to several times to man the bilge pump. The automatic pump was out of order, having been fouled by tremendous swarms of jelly fish, or sea thimbles. Hydrographic stations were out of the question, so there remained the B.T. and the

PART OF THE ARRAY *of instruments in the deck laboratory of a University of Miami research vessel. Above, left, is the G.E.K., used for measuring currents. Below is the radar panel and on the right an echo sounder tuned to record the "scattering layer."*



G.E.K., both of which could be used underway. The strongest currents were found along the edge of the shallow shelf near Cozumel Island, showing maximum velocity of about 2 knots. At no place in this crossing did there appear to be a well defined stream with a strong change of temperature as always appears in the Florida Current. It seemed as if there had been little change in the Caribbean Current throughout its traverse of the Cayman Sea. All this would suggest that some place north of the Yucatan Channel, in the southeastern quadrant of the Gulf of Mexico, the current becomes narrow and swift and shows strong temperature changes.

On the last leg, Havana-Key West, underway observations were continued which offered an amazing comparison with the first leg. The axis of the current had moved about 30 miles southward, and it had split. Its average direction was towards 100° instead of 090° as recorded three weeks previous, and it had also cooled down by three degrees F. but had increased in velocity slightly.

Like most expeditions, this one, when completed, called for further expeditions, either further east in the Caribbean Sea or perhaps concentrated in the area north of the Yucatan Channel. There is much interesting work left to do in this region, and more cruises will go out to this general area in the future.

Strange Babies

THE PHOTOGRAPH on the inside front cover is that of a young spiny lobster, or crawfish, as it is known in Florida and the West Indies. At this stage of development, the baby crawfish is entirely unlike the adult. It is a thin, transparent, leaflike creature, less than an inch long, with spidery legs and large eyes at the end of stalks. Apparently the crawfish remains a considerable period in this stage of growth, which is known as a phyllosoma. Specimens have been found at considerable distances from shore, in mid Atlantic. The life history of the western Atlantic species, found in Bermuda and the West Indies, has been studied in detail at the Miami Marine Laboratory by Dr. John B. Lewis.

SOME OF THE SMALLEST *creatures of the sea. A sample of plankton as viewed under a microscope, showing eel-like arrow worms, baby fishes, and the small crustacea upon which fishes feed.*

Big or Little

By Hilary B. Moore
The Marine Laboratory, University of Miami

We are accustomed to the idea that size makes for power and efficiency. But when we look at the creatures of the sea, the effect of size suddenly takes on a more complicated appearance.

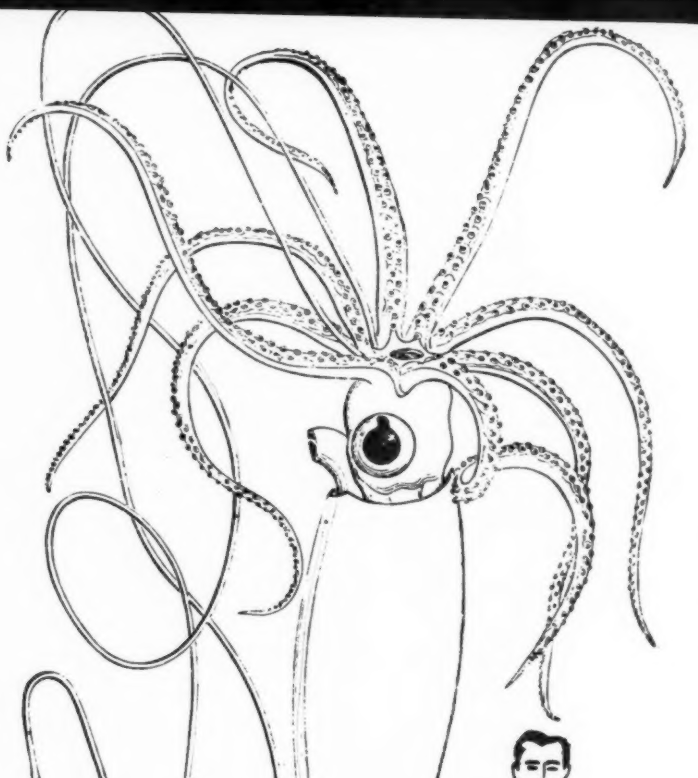
The elephant is master of the jungles, safe from attack from all smaller kinds of life—until one gets down towards the size of bacteria. To these it is just as vulnerable as a mouse. Is the elephant, then, more efficient than the mouse or the bacteria? It all depends on the measure of efficiency. A microscopic diatom in the ocean plankton doubles its size each day. Plankton animals eat the diatoms and are eaten in turn by whales, but the whales may take a year or several years to double their size. The diatom wins on speed, but at the sacrifice of size. It is difference in size, such as that between the diatom and the whale, that is—surprisingly—the key to some of their other differences.

Where the astronomer talks of distances in billions of miles, or the atomic physicist of the fantastically tiny orbits of electrons, they are in realms of size which we find it hard to visualize. Even within the everyday range of sizes, though, there are limitations which may come as a surprise. Take the elephant, for example. Could it be twice as big, or ten times? The problem is similar to that of some kind of container, a tank or, say, a kitchen kettle. If one kettle is twice as big as another of the same shape, it will hold, and so it will weigh, eight times as much. Yet its bottom is only four times the size, and so it has to carry twice as much weight per square inch. It is the same with an elephant's legs. If his length is doubled, then his weight is increased by about eight times. But if his legs are increased proportionately they become only four times as strong. So he would need to have relatively fatter legs. It is very clear that an elephant could not have its legs much fatter and still have room to move when he walks. And so an elephant is just about as large as he can ever be.

When we look into the ocean we find a very different state of affairs. We see the whale, many times the size of an elephant. In fact the whale has the bulge—in both senses of the expression—on the elephant. Its weight is supported by the water it lives in, and so it can grow to the gigantic length of eighty feet.

The shipbuilder knows another thing about size that ships share with whales and fishes. A ship two hundred feet long is about four times as hard to drive at a given speed as one of the same design but only one hundred feet long. However, it has more room in it—eight times as much. So the larger ship can carry relatively more cargo, or it has room for bigger engines, and so can go faster. In the same way the highest speeds are possible in large rather than in small fishes, since they have room for more powerful muscle engines in proportion to the friction they have to overcome. Very small fishes can never move very fast, and animals of microscopic size hardly seem to move at all. They are practically all skin and internal organs, with little muscle, and their skin friction is simply tremendous.

Why then does not everything in the sea grow large, since this allows



One of the largest *creatures of the sea, the giant squid, which has been known to grow to an overall length of 75 feet.* Architeuthis *is the appropriately lengthy name given to this giant of the deep.*

it to move faster and so to catch food more readily as well as to avoid being eaten? Well, on the latter count, the bacteria have an advantage, since they are far too small for the elephant to be able to defend itself. If they were bigger, he might be able to squash them. So, very small size may bring security against attack.

There is said to be safety in numbers, and here again size has an advantage. The elaborately built whale breeds slowly, for a very complex machine has to be duplicated. The simple single cell has, by contrast, merely to divide into two halves. With this high speed reproduction, losses in the population of single celled creatures may be very quickly replaced, whereas an overfished whale population may not recover in fifty or a hundred years. The whale is more elaborately built than a microscopic, one celled animal, and it has to be. It needs blood to carry oxygen to its tissues, and a heart to keep the blood circulating, a nervous system to keep its wide-spread parts coordinated, and an elaborate gut to handle its digestive processes. The microscopic animal has not room for all this, and does not need it. It is so small that all its parts are close to the surface, so that oxygen may diffuse easily throughout its body. In the same way food is easily diffused through the body. Sometimes the cell may just wrap itself round a particle of food and then absorb it. It needs no elaborate stomach, intestine and blood system. And being so small it needs no nerve cords and brain. Finally, reproduction can be just a process of splitting in two.

The whale and the simple animal live in the same ocean, closely dependent, since each ultimately provides food for the other. In the chain of life in the sea, each is necessary. Yet the worlds they live in, though geographically the same, are very different in nature insofar as they affect the two animals. The whale may be shot with harpoons, but very few other things with which it collides can be of serious importance. A bacterium is so small that it may be seen staggering under the blows of stray molecules which bump into it. The whale's shape is largely dictated by good streamlining. Surface tension, a minor force for the large animal, is so enormous for the very small ones that it is quite difficult for them to be anything but spherical. Even light, which cannot penetrate the skin of the whale, goes right through the small forms, threatening to sunburn not just their backs but everything inside too—a really serious danger.

We find ourselves unable to visualize vast distances with the astronomer, or ultra-small ones with the physicist. Now we find that, even within the range of size of animals, there are conditions beyond our experience, and difficult to appreciate. If we do not know our neighbors here on land, we have a long way to go before we really understand the ways of life in the sea. But that is one of the reasons that the study of marine biology is so fascinating—it is just beginning.

Looking Ahead

THE BULLETIN is mailed without obligation to those who are interested in the oceans and in the progress of scientific research concerning it.

It is hoped that, with the growing interest and advice of members and others who receive the Bulletin, it will be possible in the future greatly to expand and develop it and eventually to include articles in nontechnical language from all parts of the world, fully illustrated in color.

In order to do this, the editors welcome advice and criticism, as well as articles suitable for publication. Since the Foundation is a nonprofit organization it is necessary to support the cost of publication by extending the active membership. It is hoped that those who are interested in the objectives of the Foundation and who enjoy the Bulletin will give their support to this by bringing it to the attention of their friends.

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THE FRONT COVER shows the charter boat *Falcon*. Photograph by City of Miami News Bureau.

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THE SURFACE *of an Atlantic reef coral, enlarged*

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